Royal Australian Navy Radar

Some Historical Notes

Compiled July 2006

Preface

My father, George Woodfull Stevens (10 February 1929 to 28 December 2011), was a prolific writer in his retirement, writing and compiling several books, mainly on Australian Naval history. Since his death, I have begun the long process of sorting through boxes of photos, books and notes with the intention of eventually making as much as possible available for family and historians.

This book was published privately in 2006 solely for the contributors, and thus did not receive an ISBN. I have reassembled the original chapters to create this facsimile edition with my own ISBN. I have made it available as a PDF to the National Library of Australia as a resource for future researchers.

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Thornleigh, NSW, Australia
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Foreword

I wish to acknowledge two groups of contributors to this document. Firstly, in alphabetical order, are the ex Royal Australian Navy (R.A.N.) officers and NCOs who specialised in radar design, operations and maintenance during the years of World War 2 and in the decade which followed:

Brown	Raymond	Ch RE RAN
Chapman	Thomas	PO RM RAN
Crowley	Donald	PO RM RAN
Gregory	Mackenzie	Lt Cdr RAN
Hawke	Douglas	Ch RE RAN
Holland	George	PO RM RAN
Kerr	Leslie "Jake"	Ch RE RAN (Deceased)
King	Roy	LRM
Linton	Robert	PO RM RAN
Medley	David	Lt (Sp) RANVR
Miller	Desmond	Commodore RAN
Mooney	Kenneth	Ch RE RAN
Mowat	David	LREM (A) RAN
Robertson	William	Ch RE RAN
Saywell OAM	John	Ch RE RAN
Sharp	Gregory	Ch RE RAN
Slatyer	Robert	Lt (Sp) RANVR
Somervelle	James	Cdr RAN
Strauss	EC "Ted"	Mr (ex RN.)
Watson	Phillip "Lofty"	Ch RE RAN
Whitten	Ronald	Lt (Sp) RANVR
Wood	Gordon	Ch RE RAN
York	Gerald	Lt Cdr RAN

Secondly:

Mr Peter Kirkwood, Director of CPI Australia for access to Varian & Associates publication "How to speak radar"
Mr Ben Paternowski for his technical information on the Naval aircraft Fairey Gannet.
Dr Ian Pfennigwerth for his critiques and support in research
Mr Christopher Poole, for his information on the airborne radar ASV Mk 19B

Although this document has no formal identification such as ISBN, and its distribution is being limited to the contributors only, it does provide valuable historical information about the many issues relating to the introduction of radar into the RAN. during the period 1941 through 1955. Regrettably, due to lack of opportunity to access archive records held by the Australian War Memorial (AWM), and National Archives Australia (NAA), some of the material specific to R.A.N. ships and to particular radar types is incomplete.

George Stevens. Berowra Heights NSW August 2006.

Introduction

By Cherub Log

Most of the Radar articles appearing here have been contributed by those ex RAN personnel who were closely involved in the development, manufacture, repair and use of the then highly secret technology during the years of WW2 and immediately after. In recalling events which had occurred up to 65 years prior, it is reasonable to expect aberrations occasionally by some of the authors.

The concept of Radar had been enunciated by the German physicist Heinrich Hertz in 1888, and was later demonstrated in Germany in the early 1900s. However, nothing was done then to develop the concept, because the technology to do so did not exist. During the 1920s and 1930s the use of wireless telegraphy and wireless telephony grew dramatically, largely due to the invention and use of the thermionic valve and its derivatives. This technology was the basis for Radar to come to reality. Impending European hostilities during the 1930s added emphasis to development of the concept into a workable device which could provide a decided military advantage. By the mid 1930s, Radar was at last becoming a reality. So whereas Radar's gestation was some 50 years, comparing its difficult birth with the mature product we now see after a further 50 years of development, it was then quite Stone Age.

Although various experimental models of Radar sets had been produced since mid 1935, possibly the first successful system was the UK developed Chain Home Radio Location which commenced secret operations in July 1937. Successful trials subsequently led to the establishment of 20 RDF stations across southern England. Because of the limitations of vacuum tube technology, the Chain Home Radar operated at a frequency of 25 MHz, a wavelength of 12 metres. It was only a few years later that the British invented the cavity magnetron resonator which could produce high power pulses at a frequency of 10,000 MHz, a wavelength of 3 centimetres. This device, when used as the transmitter in conjunction with the US developed klystron local oscillator, was a quantum leap forward in Radar technology, and placed the Allied military far ahead of its Axis opponents in the science of Radar assisted weaponry. A pulsed wavelength of 3 centimetres gave a far more accurate definition of range and bearing of a target than that of a longer wavelength pulse.

In reading the articles which follow, this point of the primitive state of the art should be kept in mind. There was no Google to list thousands of references for the design teams to use. The computer was a futuristic dream, and all design calculations were done by the design teams using standard mathematical formulae, pen, paper and active brain power. A high level of secrecy was essential, which mitigated against open communication of new ideas. There was no Dick Smith or Tandy available to pick up complete units to replace and repair a fault. An Avometer, soldering iron, a few spare "tubes" and lots of trial and error were the standard tool kit for the maintenance mechanics. In combat zones under darkened ship conditions, it was common for operational and maintenance work to be done in restricted light in a confined cabin with ambient temperatures 40 degrees Celsius plus, and the unfortunate personnel occasionally retching a previous meal into a bucket as the ship rolled and pitched in heavy seas. Circuit diagrams and maintenance manuals were shipped anything up to 6 months after the equipment had been commissioned. Yet despite all these barriers, the RAN had a powerful pantry of equipment and the innovative human skills to allow Radar's effective uses in many different circumstances. The articles which follow this introduction illustrate this.

For readers with little knowledge of Radar, the article "Radar Basics" will offer simple explanations about the concept of this technology, as well as provide explanations of some of the technical words and terms used in the articles.

The terms aerial and antenna are interchangeable. Where a distance is indicated in miles, this means Nautical Miles (NM). One NM is approximately equal to 2,000 yards or 1.883 Kilometres. The original terms cycles (cs) and megacycles (Mcs) have been changed in recent years to Hertz (Hz) and Megahertz (MHz) respectively.

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Early Days

By Cherub Log & Skip Distance

In 1935, the Royal Navy's most advanced method of detecting distant objects such as enemy ships and aircraft was 7 power binoculars. Four years later at the outbreak of World War 2, the new technology variously known to the British as RDF, Radio Direction Finding, Range and Direction Finding, Radio Location, and to the USA as Radio Echo Equipment, was capable of detecting aircraft up to 60 nautical miles distant. Later the allied forces used the common terminology of Radio Detection and Ranging, which became abbreviated to RADAR.

Radar was not invented. It was a progressive development of concepts in the UK, the USA, Germany, Japan, France and Italy over a period of perhaps 30 years. These developments focused on the four main components of a Radar system, namely a radio transmitter with a pulse generator, an aerial array to send and to receive the electromagnetic pulses, a receiver to amplify and interpret the echo pulses, and an indicator such as a cathode ray oscilloscope to display the results for human interpretation.

In the early part of the 20th century, knowledge of developments in different countries was shared. A prime example is the Japanese developed Yagi directional aerial. However it became apparent that the knowledge being accumulated could be of vital security importance, and a veil of secrecy spread over the whole process in all of the technologically advanced countries from early 1930 onwards.

In February 1935 during British experiments, an aircraft was detected at a range of 8 miles as it was flying within the beam of the BBC's 50 metre short wave station at Daventry. Recognizing the requirement to create high powered transmitters operating in the ultra shortwave spectrum, experimental work resulted in laboratory models which operated at 50 centimetres, and a magnetron valve capable of working at 36 centimetres. However, at this stage, these were a long way from being incorporated in operational equipment.

The RN required short wave equipment, because longer wave equipment meant longer and bigger aerial systems, which while suitable on land, were impractical in a ship. So the RN development focus was on equipment operating in the S, C and X bands that is wavelengths between 3 and 30 centimetres. However, as shorter wavelength equipment was still very much in the development stage, the RN had to be content with the Type 79 until 1940 with the introduction of the type 281, followed by the type 271 in 1941. During this intervening period, the Type 79 under went a number of modifications, improving its range, power output, and general capability.

The RN fundamental operational approach was that Radar should be used for early warning, and that the conventional range finding process of optical range finder would then be used to track and engage the target. To this end, the RN stated objective was to have Radar which would give early warning of aircraft at 60 miles and ships at 10 miles. Further that the Radar would provide precise location of aircraft at 10 miles and ships at 5 miles. However, with the rapid advances made in the technology, it wasn't long before Radar was used for a number of functions such as early warning of ships, early warning of aircraft, gun direction and control, navigation.

The first RN ships to be fitted with type 79 Radar were the battleship *Rodney* and the cruiser *Sheffield* in early 1938. *Sheffield* did trials and reported detecting aircraft 30 miles distant at 3,000 feet, 48 miles distant at 7,000 feet and 53 miles distant at 10,000 feet. By May 1939, improved transmitting valves improved these figures by an average of 33%.

It was about this time that Australia started to take an active interest in this new secret device.

Although the UK had an operational Radio Location system (aka RDF or Radio Direction Finding) in 1937, it wasn't until early 1939 that Australia took an active interest in this secret technology. Throughout all of 1939, there was much highly secret correspondence between such luminaries as Australia's High Commissioner to UK, Stanley Bruce, the two prime Ministers Joe Lyons (who died in 1939) and Robert G. Menzies, Australian cabinet ministers, senior officers of Australia's armed forces,

and members of Australia's Radiophysics Board. A key person in this latter organisation was Dr. D.F.Martyn, D.Sc., Ph.D., A.R.C.Sc., F.R. Met.S., F.Inst. P., who was sent to UK to investigate and to report. In March 1939 Dr. Martyn sent a telegram to the PM Joe Lyons recommending that some of this RDF equipment should be purchased. The PM immediately authorised an order to be placed. One of the first recipients of the equipment was H.M.S. *Amphion*, destined to become H.M.A.S. *Perth*.

Following Dr Martyn's UK visit, a top level Australian government committee was formed to evaluate aspects of this new technology, Radio Location. The committee decided that a Radiophysics Laboratory should be established in the grounds of the University of Sydney. A further decision was that Australia should develop equipment as an alternative to relying on UK production and availability. These recommendations were fully supported by the Australian government, and steps were taken to implement the establishment of the required procedures. In broad terms, the Radiophysics Laboratory became responsible for the design and development of prototype equipment, for the training of senior personnel of the armed services and their respective support functions, and in providing training in the various scientific aspects of the operation of the equipment. The Post Master General's Department became responsible for advising the Radiophysics Board on the types of equipment required, and for the installation, operation and maintenance of the equipment.

The laws of supply and demand being no different for Radio Location than for any other commodity, coupled with Britain's preoccupation with the war in Europe meant that availability of equipment for the Australian armed forces was extremely limited. Thus the need for self sufficiency. To this end contracts were let to Amalgamated Wireless Australia (AWA), and to STC (Australia) for the manufacture of units of Radio Location models, which soon became known as Radio Detection and Ranging, which in turn became truncated to RADAR.

For the RAN, one of the first sets produced was the A272 which did sea trails in HMAS *Kybra* in November 1942. In May 1944, an upgraded version of the A272, the A276, did sea trials in HMAS *Yandra*. (See separate article by PORM "Jake" Kerr on A272/A276 comparison)

Pre war *Yandra* and *Kybra* were small coastal steamers. Both were requisitioned by the RAN, fitted with a 4 inch gun, depth charge equipment aft and port & starboard antiaircraft guns. Their prime role however was as training vessels for Radar operators, and for this they were equipped with type A286 forrard and aft, A272 forrard and aft, and 271 aft. The 271 was replaced by type A276. As well an A79 was fitted for the purpose of providing performance assessment for "Bailey Boys". (See separate article on Bailey Boys)

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A Radar Officer

(The following is an extract of a letter written 19 September 1995 by David Medley to John Saywell OAM)

By Lt (Sp) David John Medley

I was the first officer recruited directly into the RANVR for RDF duties on 1 November 1941 . This was in response to an ad which appeared in the Melbourne papers around September 1941. At that time I was the only one recruited and I suppose probably the only applicant at that time. I was transferred to the Admiral's staff in Sydney where I was assigned to the Flag Lieutenant, Lt Commander John Bath. Also on this staff was a Warrant Officer by the name of Jock Smart. Jock was a Telegraphist and had been assigned for RDF duties. He knew very little about RDF and was happy to have me aboard. Little did he know that I knew nothing about it either but I did have a Masters Degree in Physics, had been a ham radio operator for some years, and interested in electronics as far back as I could remember. This deficiency was soon rectified as I was given a crash course at the Radio Physics laboratory and access to all the classified material the RAN had at that time , which I absorbed like a sponge. After a sojourn at Flinders where I was supposed to learn how to be an officer, I was assigned to help with the RDF installations on "*Canberra*", presently refitting at Garden Island. On completion of this work early in 1942 I was assigned to her as RDF Officer. Subsequent events were recorded in "The Shame of Savo", so I will not repeat them here. (See Editor's note)

I have only the haziest recollection of the “Bailey Boys” as I never had anything to do with the training school at HMAS *Watson*. I do recall that after I returned from the Savo affair, four RAAF officers and four RAAF mechanics were loaned by the RAAF to assist in the training of RDF operators.

Also about this time (late 1942), a distinguished A/S officer, Lt Tom Cree DSO, returned from Europe and was assigned OIC of the RDF section in Navy Office Melbourne, and I essentially worked for him for the remainder of my stay in the Navy.

Even at this time I was the only officer with a firm technical background and I suppose I was regarded as something of a “Whiz Kid”. In any event I was frequently called upon to work on installations which had been beyond the capabilities of the personal (sic) concerned. I remember working on the RDF installation on “*Queen Mary*” while she was in Sydney. I remember working all night on an obscure fault in a gunnery control Radar on “*Warramunga*”, and I remember being sent to service RDF equipment on board a royal Dutch cruiser called “*Van Tromp*” in New Guinea. I remember vividly a spell in Brisbane with a US Navy submarine tender which was installing gunnery control Radars on “*Australia”* and “*Hobart”*. I was the liaison between the RAN and USN and I can recall that this was a fun time, and I learned a lot more about Radar from a Westinghouse Field Engineer who was supervising these installations.

I remember being sent to the USN PT boat bases on Guadalcanal and Savo Island sometime in 1943 to learn as much as I could about the SO Radars which the RAN had purchased for installation in the Fairmiles. These were subsequently installed at *Rushcutter* and I would suppose I supervised at least the first several installations. My most vivid recollections of this period were an overnight stay with a bunch of Coast Watchers who were waiting to be picked up by a submarine and deposited behind enemy lines and a ride on a PT boat from Guadalcanal to Savo.

As to the laboratory, I was nominally in charge of it while it was at *Rushcutter* from the time I returned from “*Canberra*” until I left the Navy in late 1945. I say nominally because I was away on special assignments a great deal of the time. On the other hand Alan Young was there all the time and will remember a lot more detail than I. The functions of the lab were as far as I can recall:

1. To provide a test facility for acceptance testing of Radar equipment being built in Australia.

2. To maintain a set of accurately calibrated test instruments which could be used to maintain standards of accuracy at RAN service bases.

3. To test new Radar equipment from overseas and to become familiar with it before it was installed in ships.

4. To develop new ideas as appropriate. In this area I worked on a Doppler Radar idea which has just now become a hot topic here in the USA. I also worked on Radar jamming equipment in the latter part of the war.

In 1945 it was decided to transfer the lab to *Watson*, and Alan and I designed a building for it. Whether this was ever built I am not sure but I do know the lab was never transferred to Watson, but was reinstalled out at the Navy Stores facility at Leichhardt sometime in 1945 – 46.

Editor’s Note. See “Shame of Savo”, by Commodore Bruce Loxton, Chapter 8 “Preliminary Moves” pages 62 on, and Chapter 23 “The Verdict” pages 254 on.

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HMA Ships 1939 – 1955 Radar Equipped

Compiled by Cherub Log

Many HMA ships were fitted with Radar, but only the larger vessels have been included in the following list. Vessels such as the Fairmile B motor launches, and requisitioned ships such as Ping Wo, Poyang and Yunnan are not included.

Ship Name	Class of Vessel	Radar Sets
Adelaide	Cruiser (ITC)	271. A290. SC.
Anzac	Destroyer (B)	275. 293.
Arunta	Destroyer (T)	285. A286. 293. 974. SC. SG.
Australia	Cruiser (C)	A286. 960. 273. 281. 282. 284. 285.
Barcoo	Frigate (R)	A276. 285. A286
Barwon	Frigate (R)	A276. 285. A286.
Bataan	Destroyer (T)	285. A286. 293. 974. SC. SG.
Bathurst *	AMS (Corvette)	A272. A276. A286
Bungaree	Aux Minelayer	NK
Burdekin	Frigate (R)	276. 285. 286
Canberra	Cruiser (C)	271. 273. 281. 282. 284. 285. A290.
Condamine	Frigate (MR)	A276. 285. A286
Culgoa	Frigate (MR)	A276. 285. A286
Diamantina	Frigate (R)	A276. 285. A286
Gascoyne	Frigate (R)	A276. 285. A286
Hawkesbury	Frigate (R)	A276. 285. A286
Hobart	Cruiser (ML)	A276. 277Q. 281AEW. 282, 285, SG.
Kanimbla ‡	AMCruiser	273. A290.
Kybra	Patrol	79. 271. A272. A286
Lae	LST	NK
Labuan	LST	NK
Lachlan	Frigate (R)	A276. 285. A286
Macquarie	Frigate (R)	A276. 285. A286
Manoora ‡	AMCruiser	A290. 273
Moresby	Survey & Escort	NK
Murchison	Frigate (MR)	A276. 285. A286
Napier	Destroyer (N)	271. A286. 291. SG. 285
Nepal	Destroyer (N)	271. A286. 291. SG. 285
Nestor	Destroyer (N)	271. A286. 291. SG. 285
Nizam	Destroyer (N)	271. A286. 291. SG. 285
Norman	Destroyer (N)	271. A286. 291. SG. 285
Parramatta	Sloop (IG)	A272
Perth	Cruiser (ML)	A286. 273. 281. 284. 285.
Quadrant	Destroyer (Q)	262. 277. 285. A286. A290. 293. 974.
Quality	Destroyer (Q)	262. 277. 285. A286. A290. 293. 974.
Queenborough	Destroyer (Q)	262. 277. 285. A286. A290. 293. 974.
Quiberon	Destroyer (Q)	262. 277. 285. A286. A290. 293. 974.
Quickmatch	Destroyer (Q)	262. 277. 285. A286. A290. 293. 974.
Shoalhaven	Frigate (MR)	A276. 285. A286
Shropshire	Cruiser (C)	273. 277Q. 281. 282. 283. 284. 285. SG.
Stuart	Destroyer (S)	A290.
Swan	Sloop (G)	272
Sydney	Aircraft carrier	277. 293. 960. 984
Sydney	Cruiser (ML)	262
Tarakan	LST	NK
Tobruk	Destroyer (B)	275. 293
Vampire	Destroyer (V&W)	A290.
Vendetta	Destroyer (V&W)	286. A290.
Vengeance	Aircraft carrier.	NK
Voyager	Destroyer (V&W)	A290.
Warramunga	Destroyer (T)	285. A286. 293. 974. SC. SG.
Warrego	Sloop (IG)	A272.
Waterhen	Destroyer (V&W)	NK
Westralia ‡	AMCruiser	273. A290.
Yandra	Patrol	79. 271. A272. A286
Yarra	Sloop	NK

* 56 Australian built Australian Minesweepers (Corvettes)
‡ Converted to Infantry Landing Ship (ILS) 1943.

B. Battle class
C. County class
G. Grimsby class
IG. Improved Grimsby class
ITC. Improved Town class
ML. Modified Leander class
MR. Modified River class
N. N class
Q. Q class
R. River class
S. Scott class
T. Tribal class
V&W. V&W Class

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Radar Types

By Cherub Log & "Skip" Distance

Of the many Radar types developed by the UK, USA and Australia, 23 were considered for use in R.A.N. vessels. With three exceptions, all were ascribed a 3 digit identification number, e.g. 277. One exception was the early UK developed 79. The other two were the US "Sugar George" SG, and "Sugar Charlie" SC. A prefix of "A" meant Australian designed and built. Suffixes of "M", "P" & "Q" meant 1st, 2nd and 3rd modification respectively. Suffixes of "X", "Y" & "Z" meant 1st, 2nd and 3rd experimental set respectively. Suffix "U" meant modification for fitting to small craft e.g. MTBs.

During her commissioned life, a ship might have had installed as many as 8 or 9 different and modified Radar types, yet carry only 3, 4 or 5 at any one time.

Admiralty classifications and examples of Radar types were as follows:

WS	Warning of surface ships. 271 272 273
WSR	Warning of surface ships and accurate ranges. 271M 272M 273M
WA	Warning of aircraft. 79
WAR	Warning of aircraft and accurate ranges. 279 280 281
WC	Warning of surface ships and aircraft close. 286 291
WCR	As WC, also accurate ranges. 290
GS	Gunnery surface low angle. 274 284
GA	Gunnery aircraft high angle. 275 285
GC	Gunnery close range. 282 283 289

The symbol § indicates that the data were not available when this article went to print. Some of the performance figures are close approximations

ID Number: 79. Manufactured in: UK. In service August 1938. Primary Function: Long range air warning. Operating Frequency: 42.827 MHz, 7 M, VHF band. Antenna: §. Output: 70 Kw. PRF: 50 Hz. Pulse: 10µseconds. Beam: §, Range: 60 NM. Display: §. Power Supplies: §.

ID Number: 262. Manufactured in: UK. March 1945. Primary Function: Gunnery close range. Anti aircraft. Operating Frequency: 10,000 MHz, 3 cm, S band. Type of Antenna: Rotating disc, 1 ½ degrees off centre, conical scanning waveguide fed, fitted to STAAG and CRBFD mounts. Output: 30 Kw. PRF: 150. Pulse: 0.5 µsecond. Beam: horiz 5.2º, vert5.2º. Range: §. Display: §

ID Number: 271. Manufactured in: UK. In service: May 1941. Primary Function: Surface warning Operating Frequency: 3,000 MHz, 10 cm, S band. Type of Antenna: Dual flat cheese half elliptical. Magnetron antenna mounted. 370 degree rotation only. Housed in a plastic lantern. Output: 90 Kw. PRF: **§**. Pulse: **§.** Beam: horiz 5º, vert 20º. Range: 25 NM. Display: Initially A scan, prior to PPI development. Power supplies: §. Type of Display: Initially "A" scan (prior to PPI development)

ID Number: A272. Manufactured in: Australia by AWA. In service January 1941. Primary Function: Surface warning of submarines and small craft. Operating Frequency: 3,000 MHz, 10 cm, S band. Antenna: Dipole in parabolic reflector. 370º rotation hand driven by "M" type transmission. Galvanised iron waveguide. Housed in timber lantern. First Australian magnetron fitted set. Output: 10 Kw. PRF: 50. Pulse: §. Beam: §. Range: 25 NM. Display: "A" scope in Radar office. Power supplies: 230volt 50 cycles.

ID Number: 273. Manufactured in: UK. In service: January 1941. Primary Function: surface warning Operating Frequency: 3,000 MHz, 10 cm, S band. Type of Antenna: Double cheese. Receiver above, transmitter below. Gyro stabilised. Magnetron mounted on the antenna. Output: 70 Kw. PRF: §. Pulse: §. Beam: §. Range: 25 NM. Display: "A" Scope. Power Supplies: §.

ID Number: 275. Manufactured in: UK. In service: January 1945. Primary function: Gunnery control high and low angle. Operating frequency: 3,000 MHz, 10 cm, S band. Type of Antenna: Two nacelles, transmitter starboard side, receiver port side. Output: 400 Kw. PRF: 600. Pulse: 0.5 µsecond. Beam: horiz 4.8º, vert 5.2º. Range: §. Display: §. Power supplies: 180 volts 500 cycles. (Was part of the Flyplane Predictor System).

ID Number: A276. Manufactured in: Australia. In service: January 1944. Primary Function: Surface warning. Operating Frequency: 3,000 MHz, 10 cm, S band. Type of Antenna: Parabolic small single dish, continuous rotation, stabilised in azimuth.. 10 RPM in either direction. 80 degree sector sweep. Output: 500 Kw. PRF: 500. Pulse: §. Beam: horiz 3.5º, vert §. Range: 16 NM. Display: PPI. Power supplies: 180 volts 500 cycles.

ID Number: 277P. Manufactured in: UK. In service: September 1943. Primary function: Surface and air warning. Operating Frequency: 3,000 MHz, 10 cm, S band. Type of antenna: AUK was approx 1.35 metres in diameter circular dish being waveguide fed rotating at 18 rpm. The Antenna could be elevated for aircraft slant height ranging. Power output: 400 Kw. PRF 500. 1.9 µsecond pulse. Beam horiz 4.5º, vert 4.5º Range 35 NM. Display: HPI design B. Power supplies: 180 volts 500 cycles.

ID Number: 277Q. Manufactured in: UK. In service: January 1944. Primary function: Surface and air warning. Operating frequency: 3000 MHz, 10 cm, S band. Type of antenna: ANU parabolic reflector rotating at 18rpm. The antenna could be elevated for aircraft slant height ranging. Power output 500 Kw. PRF 500. 1.9 µsecond pulse. Beam horiz 4.5º, vert 2.5º. Display:HPI design B. Power supplies:180 V 500 cycle..

ID Number: 281. Manufactured in: UK. In service: December 1940. Primary function: Air search. Operating frequency: 90 Mcs, 3,3 metres, VHF. Antenna: Separate dipoles for receiving and transmitting. Transmitting antenna mounted on mainmast and fed by twin wires with spreaders of plastic at approx 70 cm intervals. Receiving antenna mounted on foremast and fed by pyrotenax Coaxial fed. 5 rpm. Output: 600 Kw. PRF: § Pulse: §. Beam: horiz 40º, vert §. Range: Up to 100 NM. Display: "A" scope. Power supplies:

ID Number: 282. Manufactured in: UK. In service: §. Primary function: Gunnery control. Operating frequency: 180 Mcs, 1.67 metres, VHF band. Antenna: Yagi attached to the Director and controlled by the Director. Output: 15Kw, output valve was micropup. PRF: §. Pulse: §. Beam: §. Range: §. Display: §. Power supplies: 180 volts 50 cycles.

ID Number 283: Manufactured in UK. In service September 1942. Primary function AA Fire Control. Operating frequency: 180 Mcs, 1.67 metres. VHF band. Antenna §. Output: 15 Kw. PRF: §. Pulse: §. Beam: §. Range: §. Display: §. Power supplies: §

ID Number: 284: Manufactured in: UK. In service: December 1940. Primary function: AA Fire Control. Operating frequency: 599,584 Mcs, 0.5 cm L band. Antenna: § on top of director. Output: 25

Kw. PRF: § .Pulse: §. Beam: §. Range: 10 NM. Display: §. Power supplies: §.

ID Number: 285: Manufactured in UK. In service January 1941. Primary function: AA Fire Control. Operating frequency: 180 Mcs, 1.67 metres. VHF band. Antenna §. Output: 15 Kw. PRF: §. Pulse: 15 µsecs. Beam: horiz 20º. Range: §. Display: §. Power supplies: §.

ID Number: A286P. Manufactured in: Australia. In service: January 1941. Primary function: Surface and air warning. Night warning of surface craft up to 6 nautical miles. Would detect aircraft up to 86 NM depending upon aircraft altitude. Operating Frequency: 176 MHz, 1.7 metres, VHF band. Antenna: 286M fixed Yagi later replaced by 286P rotating bedstead array having horizontal dipoles. Rotation caused by hand operated Bowden cable for 370º rotation, later replaced by "M" type system. Output: 100 Kw via coax to antenna. PRF: 1000. Pulse: 2 µseconds. Beam: §. Range: §. Display: "A" scope in Radar office. Power supplies: 80 volts 1000 cycles.

ID Number: A290. Manufactured in: Australia. In service: 1941. Primary Function: Air search. Operating Frequency: 200 MHz, 1.5 metres, VHF band. Antenna: Yagi with 4 directors and 3 reflectors. Output: 100 Kw. PRF: §. Pulse: 0.5 µsecond. Beam: §. Range: §. Display: §. Power supplies: §.

ID Number: 293. Manufactured in: UK. In service: January 1944. Primary Function: Combined air and surface warning. Operating Frequency: 3,000 MHz, 10 cm, S band. Antenna: Copper waveguide horn fed parabolic reflector, controlled by "M" transmission. Output: 500 Kw. PRF: 500. Pulse: 0.4 µseconds. Beam: horiz 2.5º, vert §. Range: §. Display: §. Power supplies: 180 volts 500 cycles
ID number: 960. Manufactured in: UK. In service: 1946. Primary function: Surface & air warning. Frequency: 88.175Mcs, 3.4 metres, VHF band. Antenna: Horizontal dipoles in grid array coaxial fed, continuous rotation 15 rpm. Output: 400 Kw. PRF: 250. Beam: horiz 35º, vert §. Range: §. Display: §. Power supplies: (see below).

ID Number: 974. Manufactured in: UK. In service: §. Primary Function: Navigation - high definition surface warning. Operating Frequency: 10,000 MHz, 3 cm, X band. Antenna: Dual cheese parabolic waveguide fed continuous rotation. Output: §. PRF: §. Pulse §. Beam: §. Range: §. Display: §. Power supplies:

ID number: 984. Manufactured in: UK. In service: §. Primary Function: Combined air and surface warning. Operating Frequency: 10,000 MHz, 3 cm, X band. Antenna: Dual cheese waveguide fed. Output: §. PRF: §. Pulse: §. Beam: §. Range: §. Display: §. Power supplies: §.

ID Number: SC4, Sugar Charlie. Manufactured in: USA. In service: July 1943. Primary Function: Air warning. Operating Frequency: 9338 Mcs, 3.2 cm, X band. Antenna: §. Output: 7 Kw. PRF: 1000. Pulse: §. Beam: horiz 1.6º, vert 23º. Range: 25 NM. Display: §. Power supplies: §.

ID Number: SG. Sugar George. Manufactured in: USA. In service: February 1942. Primary Function: Surface warning. Operating Frequency: 3,000 MHz, 10 cm, S band. Antenna: Semi elliptical parabolic single antenna waveguide fed. Motorised rotation. Stabilised in azimuth 24 rpm. Output: §. PRF: §. Pulse: 2µseconds. Beam: horiz §, vert §. Range: §. Display: PPI

ID Number 960: (Notes provided by Ch. RE Gordon Wood). This long range warning set had better performance than 281. The display and control system was easy to operate. 960 had a range of 200 NM. It was fitted in cruisers and was associated with 277 & 293 for an integrated air warning system. Power supplies were common for these 3 sets and associated IFF. There was a master trigger for all transmissions. There were 3 versions of 960 each with a different antenna system. 960 with AQQ antenna had separate arrays for spot frequencies of 86, 88 and 90 Mcs. 960M had antenna system ANA, which was a light weight antenna and operated between 80 and 90 Mcs. 960P had antenna system ANB operating at 80 to 90 Mcs. It was installed on aircraft carriers and had a large screen for data presentation. Frequency variation in the various models of 960 was achieved via a manually operated selsyn.

The main power came from a special alternator comprising one 250 and two 500 cps machines synchronized mechanically simply by being driven on one shaft. The 250 cps machine provided power to the 960 modulator. One of the 500 cps machines provided power to the other txs associated with

960, and the second 500 cps machine provided power to the receivers and displays. Power delivery of the alternator ranged between 6 and 18 KVA.

The modulator gave 5 & 15 µsecond pulses at a PRF of 250. Peak power output was between 400 and 450 Kw. The 960 took 30 minutes to warm up, and 1 ½ minutes to switch on. Cathode followers allowed up to 8 PPIs and 3 sector displays to be connected.

Ranging Units RTB & RTE. While not Radar sets , these units were used in conjunction with the PPI and TPI displays to provide accurate ranging for both long and close range armaments. The 3 ranges were 0 to 10,000 yards, 0 to 36,000 yards and 0 to 100,000 yards.

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GCI Radar

Introduction by Cherub Log

GCI Radar was a very early ground installation, coming into service in the UK possibly 1937. GCI stood for Ground Control Interception, and as such was used by the RAF for vectoring in British fighter aircraft to approaching German attack aircraft. When the RAN established its Fleet Air Arm base at HMAS Albatross in the late 1940s, a Type GCI was installed near the intersection of the runways 21 and 26. It is believed that the system had a dual role of GCI and GCA, Ground Control Approach. This was one of five navigational aids to aircraft control at HMAS Albatross. The others, mentioned in other articles in this collection were the Type 277 Q 10 cm radar installed on nearby Nowra Hill, the FV5 VHF Direction finding equipment installed 1 Km south of the control tower, the AH6 HF DF installed 1 Km north of the control tower and the YG beacon, installed on Nowra Hill. Thus the risk of losing an aircraft during night flying exercises was quite low.

GCI by E.C. “Ted” Strauss

As an “on loan Pom” in the early to mid fifties, I spent some time as the LREM at the GCI site at RANAS Nowra, and really enjoyed the experience being the only Radio Mech on site. Lt Cdr Brasch was the Air Direction Officer at the time. Today he would be called SATCO. He appeared to have more faith in the GCI than he did in the more modern 277 installation on Nowra Hill. All three of us, Brasch, me and GCI, got along well together.

The GCI was an early Radar , made in about 1935 or 1936, with a rotating aerial and operating in the 200 Mcs band. Display was a PPI showing range and bearing, and an “A” display from which target height would be calculated. Power output was in the region of 100Kw peak, and the PRF would lie between 150 and 350 PPS. The antennas a wooden frame mounted on a wooden hut, all of which rotated. The frame was covered in chicken wire and mounted two horizontal rows of dipoles which were switched in such a manner as to result in three transmitted lobes, thus giving height cover from 4 to 30 degrees above horizontal. The aerial was fed by an open pair. In the Nowra installation, the range and bearing information was transmitted via a locally designed transmitter feeding a Yagi array to remote displays in the control tower.

The original system was an on-site console housing some of the electronics, and the PPI and “A” scan displays for the operator’s use. Target height calculation was by means of a chart with range and decimal fraction axes. From the “A” display the operator assessed the fraction of a second echo of a target with respect to the primary echo, and used this fraction and the range to read the altitude off the chart. I had the experience of operating the height plot on an occasion when due to sickness there was a shortage of Radar Plotters coupled with an important exercise. For the age of the system, the height plotting was remarkably accurate.

<u>Cherub Log’s note:</u>

“Ted” Strauss has provided good quality photocopies of the major circuits which together made up the Type GCI. These circuit diagrams, dated September 1947, are as follows:

Control Unit 181. GCI Multivibrator unit. Intensifier unit. Monitor unit. Transmitter unit. Switch unit type 38. Calibrator and phase splitter. Modulator unit.RF unit. Amplifier type A3175. IF unit. Aerial rotating gear. Turning gear Bloc diagram.

Some of the thermionic valve types used are as follows:

IF Amplifier, VR 91pentodes. “A” scan monitor VCR112. Modulator SP41 pentodes and VT127 tetrodes. Calibrator and phase splitter KTZ41 tetrodes. Multivibrator unit VR91 pentodes. RF preamplifier RL7 pentodes. HT DC supplier from two V1901 rectifiers. Transmitter two VT 98A triodes

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A272, A276 Comparison

By “Jake” Kerr. PO RM

As I recall the A276 antenna control, it had a 3 position switch which allowed “Continuous”, “Manual” or “Sector” mode of operation. “Continuous” gave a turning rate of up to 10 rpm in either direction via a Centre Zero Pot. “Manual” gave control to a small crank handle, i.e. the antenna would auto-follow in either direction as fast as the handle could be turned. “Sector” allowed the antenna to be positioned manually on a desired bearing, and a Sector Pot controlled the angle of the swept sector about this bearing, i.e. 5- 10 – 20 – 30 – 40 degrees of sector. The antenna table for the A276 was stabilised in azimuth, i.e. the PPI coil drive was stabilised

The A272 was a completely different kettle of fish from the A276. The antenna was modeled on the English 270, and consisted of two cheeses mounted one above the other. The lower transmitted, the upper received. The cheeses were about 4 or 5 feet across the horns, and the whole antenna stood about five feet high. It was contained in a plywood lantern, approximately 8 feet in diameter and 5 ½ feet high. The antenna was mounted atop the 20 inch Searchlight platform. Access to the antenna itself was via a removable plate in the lantern base.

The antenna was motorised using the same system as the BAP/H/M (for A286Q) i.e. the AS1 and AS 3 ASDIC controllers. Rotation was limited to 360 degrees, with a 5 degree overshoot each side of dead astern via a pair of traveling limit switches. It was stabilised in azimuth.

A 10 centimetre pipe from the transmitter terminated just inside the base of the lantern. Here it was matched to a 75 Ohm cable which went once around the antenna base (to allow for rotation) before terminating on fixed plumbing at the back of the cheese. The fixed plumbing went through the base of the cheese to within 6 inches of its front, where it ended in a 20 cm dipole (tuneable). The RF from the dipole was reflected by a plate across the front of the cheese, and came roaring out of the cheese in a solid beam. The Rx system was identical with a separate 10 cm pipe at the back of the receiver. (No TR switch – how primitive!).

Like the A276, the A272 was a spark gap modulated job. But here the similarity ends. The Tx/Mod unit was contained in a standard AWA crackle finish box about 3 feet wide, 1 and ½ feet deep, and 4 feet high. The top 1 foot section was the Tx, and the rest was the modulator. (For Tx maintenance it was necessary to lift the Tx clear of the Mod locating studs, and remove the front of the unit. Considering the weight of the old magnetron permanent magnets units, it can be understood why Corvette Radio Mechanics had weak wills and strong backs). To make matters worse, the unit was positioned just outside the door of the Skipper’s cabin, and under the bridge ladder. In an attempt to protect it from sea water, a metal cabinet had been added, which further restricted access. However the cabinet did screen out some of the Tx noise.

Inside the grey crackle box, the modulator was a fairly conventional thing. A couple of front panel switches, a form of Variac, power transformers, C-1, a resonant line, and a rotary spark gap. The Tx, in the upper tray, consisted of a magnetron and associated pieces, plus an odd piece of tunable plumbing which matched the output of the magnetron to the 75 Ohm cable and the 10 cm antenna feed pipe. The spark gap was another odd thing. It was like the double ended rotary spark in the A286Q, except that

the stator of the motor could be moved manually to correct the phase of the spark. (one could tune for maximum smoke!)

The other difference was in the spark gap itself. The fixed set-up here was a point on one side, and a ball on the other. The rotating bit consisted of a ball on one side and a gramophone needle on the other. So the spark jumped from a fixed point to a rotating ball, then from a very fine moving point to a fixed ball. The needle points were replaceable, and as a Naval Stores item, their progression was from Naval Stores for service in the SRE gramophone, and then to the A272.

The Radar office did not change much when the A276 replaced the A272. In the 20th Minesweeping flotilla the A276Q was on the right as the door was opened, with the 2 A272 racks next in line. All 3 racks faced forward. This compartment was formerly the Skipper's bathroom, and under the racks, the four feet of the removed bath could be seen clearly. This compartment measured 5 feet by 5 feet by 8 feet high. When facing the 2 A272 racks, the one on the left was 4 feet high, the top 12 inches of which sloped slightly backwards. This was where the A scan was mounted (a complete A276 A scan). Immediately below this was the AS3 antenna control, with the AS1 Relay Panel in the next drawer down. The rack on the right was full height. The receiver waveguide terminated on the deckhead immediately above this one, with a 75 Ohm cable finding its way down to the front of the receiver about 12 to 18 inches below. The first panel down was the Radio Mechanic's hideaway. It contained ALL of the test equipment (a model 7 Avometer), both equipment manuals, and a carton of Craven A.

Next was the receiver, which was a prototype of the one in the A276. Then there were the trays containing the cumbersome power supplies.

The switches and regulators etc for starting the Rotary Power Supplies were all located on the forward screen of the office. The A4 motor alternator for the A286Q was located about 4 feet off the deck in the Barbette for the 4 inch gun (on the sailors' mess deck). The forward "donk" for the W/T office was immediately below it. The A7 motor alternator for the A272 was mounted at deck level outside the Coxswain's office/cabin. It served 3 purposes in life. One was to supply the Radar, another was to supply the clippers of the Chief Stoker's Hairdressing Firm, and the third was to keep the Cox'n awake at night

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Identification Friend or Foe (IFF)

A paragraph in the article Ancillary Devices will provide a general description of IFF. This information in this article which has been provided by Ch RE Gordon Wood provides some details of some of the specific units

<u>242 Interrogator (With 293Q Radar)</u>

The Mk 3 IFF system comprised a transponder which swept 3 small frequency bands allocated to Identification Operations. The transponder was actuated by an interrogator signal emanating from a low power transmitter receiver associated with the main radar set. Radar and interrogator transmissions were simultaneous, thus the response and echo returned together. The operating frequency was capable of being changed quickly and easily because of enemy jamming.

The transmitter design allowed high (10 Kw) or low (2Kw) power output. The frequency could be varied in a band of about 30 Mcs between 157 and 187 Mcs.

The transmitter and preamplifier contained an oscillator, series modulator and built in power unit, a preamplifier for the responsor, a gas gap TR switch for connecting the TX and responsor preamplifier to the common aerial and artificial load for measuring Tx output. The series modulator received its initiating pulse from the radar transmitter pulse, delayed by 3 μseconds. This caused the oscillator to transmit.

The essential link between the radar set and the interrogator was the modulator and mixer unit whereby the interrogator Tx pulse was synchronised as a sub multiple of the radar pulse rate.

The responsor was a superhetrodyne receiver having 1 RF stage, local oscillator, diode mixer, 5 IF stages, diode detector and video amplifier.

The aerial array was a chandelier type with dipoles and reflector assemblies. These comprised two dipoles connected in parallel and mounted half a wavelength apart. Each dipole had a single reflector fixed approximately 1/5th of a wavelength behind the dipole. The aerial was fed by unbalanced pyrotenax cable.

242P Interrogator (With 277Q Radar)

Intended to be displayed on a UDU (Outfit JM) principally. This was similar to Outfit JH in that radar signals were sector selected and presented on upper trace, while IFF signals were continually shown on the lower trace, except during signal selection. The interrogator aerial turned with the radar aerial. As with the UDU, the IFF signals were being compared with faint after glow of a short bright trace. High brilliancy was not required and the repetition rate could be low.

251M

This was a beacon fitted in surface craft which may have been required to work with ASV fitted aircraft. When installed ashore it was known as 251M/S, and was used as a means of indicating the section of shore under consideration to an aircraft fitted with interrogator at the right frequency. It had 3 functions:

1. It enabled ASV fitted aircraft to determine the range of the beacon.
2. It operated a warning light which indicated that a signal was being received. In aircraft carriers the light was fitted in the ADR.

3. It enabled messages to be sent to the ASV apparatus or interrogator by substituting a handkey for the automatic coding device.

The components were Power supply, Control panel and auto voltage control gear, Distributing board and rectifier unit, Transmitter 7AB, Receiver P27 or P27A, Aerial feeder system, Remote indicator unit. Under favourable conditions, a range of 70 miles could be obtained with aircraft flying at 2,000 feet. With ASV/X (Lucero), the range was reduced to 55 miles.

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Ancillary Devices

By Cherub Log and "Skip" Distance

In keeping with the focus of the articles in this collection, what follows here is a brief introduction to those electronic devices which were developed and used in conjunction with Radar. These were:

1. IFF. Identification Friend and Foe
2. DF. Direction Finding, MF, HF and VHF
3. Loran. Long Range Radio Navigation.
4. Radio Beacon
5. Radio Altimeter
6. Radio Compass
7. Typex encryption machine
8. Sonobuoy

1. IFF. Identification Friend and Foe.

This system was developed as ship borne and airborne equipment. Both operated on the same principle which was an automatic signal being transmitted from an interrogator to a target (ship or aircraft). If the target was fitted with a corresponding transponder, an automatic signal would be sent back to the receiver unit of the transmitting interrogator, and displayed on the Radar screen. In this case the target would be deemed "Friend". Should there be no response from the target for any one of a number of

possible causes, it would be deemed “Foe”. Security was provided by coding which could be manually incorporated into the units of the system. Thus if the enemy had access to the system units, he would also have to know the code settings for the day or time of operation in order to make effective use of the equipment.

The operational sequence for a ‘Friend’ was firstly a signal would be transmitted by the Interrogator’s transmitter. This would be received in the receiver unit of the Friendly Transponder which in turn would respond automatically by transmitting a response. The response would be received by the Interrogator’s receiver unit, called a Responsor, and a coded signal would be displayed on the associated Radar’s PPI or other display unit.

The ship borne interrogators were 242, 243, 941, 944. The ship borne transponders were 253, 954. The airborne AN-APX1, carried by all R.A.N. aircraft was a transponder only. The AN-APX 2, carried by Fireflies Mks 5 & 6 only, was an interrogator and transponder. (See separate article by Ch RE Gordon Wood)

2. DF. Direction Finding.

This was a device developed to provide an aircraft with information about its bearing relative to its operations base, whether this was a ground station or aircraft carrier. Normal HF or VHF transmissions from the aircraft would be received by the base receiver, such as AH6 or FH4 for HF and FV5 for VHF, and the relative bearing of the aircraft to the base would be automatically displayed on a PPI screen. This information could then be relayed to the aircraft via the usual HF or VHF communication channel. There was also a little used MF version, the FM12.

3. LORAN. Long Range Radio Navigation.

This is a device developed to aid in ship navigation over long distances. Typically 3 transmitting stations in a group would operate on the same frequency. All transmitting stations would be fixed and of known latitude and longitude. One station in the group would be the Master and the others the Secondaries. The principle of operation was to create pulsed signals at precise time intervals, such that a receiver tuned to the group frequency could compute the time differential between the Master and the Secondary signals, and from this derive a rough fix on the latitude and longitude of the receiving ship or aircraft. To provide world wide coverage, the fixed base Loran transmitters were high power and operated in the HF range at around 100 MHz.

LORAN could cover a vast geographical area, but its definition for close navigation was unsatisfactory. To address this need of a reliable navigational aid in confined waters where shipping traffic was heavy, such as the English Channel, the “Decca Navigator” was introduced. Unlike LORAN, the principle of this system was that it used continuous transmission, and the phase differences of received signals from a number of relatively close shore based fixed sites were measured to establish the position of the receiving vessel. In the 21st century, Loran is still used extensively, in particular in the European community, as it is regarded as a safe alternative to other global positioning systems.

4. Radio Beacon.

This device was a VHF transmitter with a slowly rotating directional aerial. Within every twenty four 15 degree sectors of the compass, the transmitter would transmit a Morse code symbol twice. For example, in the sector north through 15 degrees east the Morse signal might be A (dit dah). Then in the next sector North 15 degrees east through N 30 degrees east the signal might be O (dah dah dah). And so on with a different Morse signal for all of the 24 compass sectors. Upon receiving these audio signals, the aircraft crew would know in which general direction lay their base. The transmitters were YG beacon for land based and YE beacon for ship based transmitters. The aircraft installation was ZBX.

The advent of GPS has improved considerably the navigational assistance available to ships and aircraft.

5. Radio Altimeter (AYF)

This radio device operated on a principle different from that of Radar. The Radar principle is that the frequency of the signal is fixed and a comparison is made of the time of the transmitted signal with the different time of the returned signal. (See discussion on Doppler Effect in the article Radar Basics). In the radio altimeter, the transmission is frequency modulated, i.e. continually changing at a predetermined frequency. It is the frequency of the transmitted signal which is compared with the different frequency of the returned signal that is used to compute the aircraft's altitude. Note that this system is quite independent of atmospheric pressure which is the basis for regular altimeter construction. The transmitted frequency was frequency modulated at 120 cycles per second. At the higher range of 4,000 feet altitude, the operating frequency was 442 to 446 Mcs, and at the lower altitude range the operating frequency was 420 to 460 Mcs

6. The Typex Encryption Machine.

The Germans invented the "Enigma" machine in 1926. It wasn't until 1936 that the British decided to have their own machine cryptograph for enciphering all radio traffic. The Typex was based on the Enigma, but the early versions were quite inferior in design and operation when compared with Enigma. This was evident when the British troops were forced to evacuate Dunkirk, a number of Typex machines were left on the beach. Discovered by the Germans, the machines were simply destroyed as the Germans knew the Typex limitations. Various improved models were progressively developed, but it wasn't until the Mark VIII Typex was released that the British had a machine capable of receiving and transmitting Morse code signals and automatically causing plain text to be printed.

The Typex was an electromechanical device, with no electronic circuitry, simply direct current. It was essentially a standard typewriter keyboard connected to a teletype machine, but with infinitely variable internal electrical connections via a series of notched circular rotors. Each rotor had 26 double electrical contacts on both ends. Each contact on one end of a rotor was hard wired to a contact at the other end, but each rotor was wired differently from all others. Typically 25 rotors, each identified by a unique number, were supplied with a Typex device, and typically 5 rotors would be fitted to the machine at any one time. One rotor was static and the others rotated. Each day, the rotor sequence would be changed, not by moving the rotors but by a plug board, similar to the very early manually operated telephone exchanges. Every Typex had to be changed identically and co-incidentally for the whole communication system to operate correctly. Thus via the transmitting and receiving Typex machines, encrypted electronic messages could be securely exchanged. Typex machines remained in use until the early 1970s.

7. Sonobuoy.

Early sonobuoys were non directional. Each cylindrical canister which contained the detecting and transmitting equipment was about 80 centimetres long and 12 centimetres in diameter. At the base of the cylinder was a hydrophone connected to the transmitter via an electrical cable 10 metres long. At the top of the cylinder was a whip aerial attached to the cylinder by a coil spring, and restrained against the cylinder by a quick release clip. Upon being dropped by the aircraft, impact with the water surface would cause three actions to occur. One would be to release the hydrophone which would descend in the water until stopped by the connecting cable. Secondly the aerial quick release clip would disengage, allowing the aerial to spring up and assume a vertical orientation. Thirdly the battery power to the amplifier and transmitter would be switched on, and the device would be in immediate operational mode. Operational frequency range was 62.9 to 71.7 Mcs. Effective range was a maximum of 3 miles. Battery duration was 4 hours.

Non directional sonobuoys were generally tuned to one of 6 different frequencies. As a pattern of sonobuoys was dropped, the observer would note the relative position of each one, such that when a target created audio noise was picked up by the hydrophones, the observer would know the approximate position of the target by tuning his receiver to the preset transmitter frequencies.

Later versions of sonobuoy had directional hydrophones, which meant that as few as 2 would need to be dropped in a pattern in order to get a fix on a target.

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H.M.A.S. Bataan

By Donald Crowley. HO PO RM

P. O. R. M. Don Crowley was drafted to HMAS Bataan early 1945 immediately prior to her being commissioned, and supervised the installation and testing of the US SG surface warning, and the US SC air warning Radars. This equipment was located in the Navigator's chart room. As examples of the types of problems encountered in those early days, when it was imperative to "get the stuff in and sort out the problems later", Don recalls the following incidents he encountered in Bataan

One was an interesting phenomenon which came to light in the early stages of comparing the ranges with those of the optical range finder in the gun director. In theory, the ranges should have been precisely the same, but they were different by a small amount. After examination of the data, it was reasoned that there was a perceptible time delay in the transit of the Radar transmitted signal from the transmitting magnetron to the antenna, and similarly of the returned signal from the antenna to the receiver. Once calculated and applied into the ranging calibration, the factor remained constant until associated components were changed. The satisfying outcome was that there were no more arguments between the gun director and Radar plot crews as to which range was correct. This phenomenon was also noticed in the early days of television when because of the different cable lengths, the time taken for the video signal to travel from the various studios and outside broadcast units to the central operations room, the telecine, was different in every case. The TV solution was simply to delay the shorter path signals to equate to that of the longest path.

Pre commissioning trials are essential to ensure that as far as possible, all predictable problems have been resolved. Not quite so in Bataan's case where Full Astern had the desired effect on ship's speed, but the undesired effect of the generated heat melting the cables running up the mast, rendering all Radar instantly inoperative. So it was back to the dockyard for installation of protective heat shield on the mast cables.

Another problem was that the SC Radar did not perform well. Investigation revealed that the coaxial cables were below specification, and upon replacement showed a receiver signal gain of about 6db, quite significant.

Yet another was the difference in ranges of SG's PPI and the "A" scan displays. The PPI's extreme range was greater than that of the "A" scan, but this anomaly was not apparent until on one occasion the "A" scan operator was almost accused of being asleep because he did not detect an echo which had been detected and reported by the PPI operator. The alternative solutions were to either decrease the PPI maximum range to be coincident with that of the "A" scan, or to accept the fact of a design limitation. The later course was adopted, and henceforth when operating on maximum range, the PPI operator invariably would see a "blip" before the "A" scan operator did so.

Footnote: Jim Somervelle recalls that in 1947/48 Bataan had 2 US Radars. One was surface warning SG1 (Sugar George), and the other was SC4 (Sugar Charlie).

Don recalls that Shropshire had a potentially disastrous installation misadventure when fitting out in UK. Type 282 Radar was installed in the port and starboard small arms batteries, the pom poms. During an early workup exercise, aircraft simulating a port side attack were detected on the starboard system. Investigations revealed that the port antenna system had been connected to the starboard Radar and vice versa.

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HMA Ships *Canberra* 1 and *Shropshire* Radar Equipment Fitted.

By: Lieutenant Commander Mackenzie J. Gregory RAN Ret'd.

I served in HMAS *Canberra as* a Sub Lieutenant RAN from December 1941 until she was sunk at the Battle of Savo Island on the 9th. of August 1942. At the commencement of that Battle I was the Officer of the Watch on her bridge. *Canberra's* Radar Officer was David Medley.

About May of 1942, as part of a refit in Sydney, *Canberra,* was I believe, the first RAN ship to be fitted with Radar. She had the British Type 271 Radar set fitted, and Sub Lieutenant David Medley RANVR both fitted this set, and became the ship's Radar officer. I must say it was still considered a Black Art by senior officers.

Although we had picked up the US destroyer *Blue* on patrol on the seaward side of Savo Island at a distance of 30 miles previously, with misty weather on the night of August 8/9, we certainly did not detect by our Radar 271, the approaching Japanese surface force. But then neither did *Blue* or *Ralph Talbot* on picket duty, either see the Japanese visually, or pick them up on their Radar.

David Medley, post war went off to live m the United States and became a naturalised US citizen, and still lives there. In 2004 we corresponded, and he had this to say about the Radar fitted in *Canberra.*

"I have never forgotten the short time I served on *Canberra* and have been haunted throughout the years about what I could or should have done to make the more senior officers aware of the capabilities of the Radar equipment on board. 20/20 hindsight is always misleading and I constantly remind myself that in those days an RANVR Sub Lieutenant, wet behind the ears, was regarded as the lowest form of animal life, and not to be taken seriously. I doubt that Capt Getting even knew that I existed. He certainly never exhibited the slightest interest in the Radar installations.

I noted with interest that you served on *Shropshire*. I wonder sometimes why I was not given the opportunity to join *Shropshire* but I don't believe that subject ever arose. Although the court of inquiry absolved me from any blame I guess some stigma may have stuck to me. I was never sent to sea again except on short cruises involved with my work in developing new Radar for the navy which was what I was better fitted for anyway.

You and Bruce Loxton are the only members of the *Canberra* gunroom that I remember clearly. I suspect that this is because you were the only two people that were interested enough to ask about the Radar installations."

At the time, *Canberra's* Gunnery Officer was Lieutenant Commander D. M. Hole RAN, killed at the Battle of Savo Island 9/8/1942.

HMAS *Shropshire.*

I served in HMAS *Shropshire* as a Lieutenant RAN from December 1944 to mid 1946, she had a wonderful ship's company and was a happy and lucky ship. The fact that we did not lose a man to enemy action was, I believe, largely due to her Radar equipment fitted, and the great Radar operators who manned them. Our Task Force Admiral would signal to ships in company "Pay *attention to Porthole's Radar reports, SHE IS HOT STUFF! "*

Shropshire's Radar sets fitted were:

Type 281. Air warning. Frequency 90 Mcs. The transmitting antennas fitted on the mainmast and the transmitter was in the office at the base of the mast. The receiving antenna was fitted on the foremast, and its receiving office fitted on the flag deck at the foremast's base. The antennae rotated in synchronism.

Aircraft reports on planes went off to the Air Defence Office manned by Radar rates with Lieutenant Ron. Major in charge, here both enemy and friendly aircraft were plotted, and this office was in touch with ships in the Fleet by voice signal. The ship's famous call sign *"PORTHOLE"* was often on the

air, and we were well known for the quality of our Radar warnings of enemy aircraft. In perfect weather conditions, Able Seaman Joe Barrington MID, who could read round the curved edge of the Radar screen could report the enemy as far away as 120 miles.

Type 273. Surface Warning. lOcm wavelength. 3,000 megacycles frequency. Antenna which was gyrostablised was in a lantern type structure on top of its office which in turn was located just forward of the after control. This set connected to an accurate range display panel in the transmitting station.

Type 274. Main Armament.

Antenna mounted on the main armament director located above the bridge, just forward of the foremast. Its office was below decks, and range and bearing for the main 8 inch gun armament was supplied to a display panel in the main transmitting station.

4 Type 283 sets. Auto Barrage Units.

There was one of these sets for each of the four 8 inch gun turrets, and each had a control station with a display unit on the upper deck. The main office for these units below decks. The objective of the 283 sets was to enable efficient use of the main armament against dive bombing attacks, and they proved useful against the Kamikazes. Each of these sets had a small fire control device like a mechanical computer. The main armament guns could be loaded with shells fitted with a time fuse, generally set for a different time in each gun barrel, the FC Device would work out the correct time, and fire the guns so that when the shell exploded, it was at the same place as the aircraft would be if it flew on at the same course and speed.

Type 285. 4 inch Antiaircraft Guns.

Antenna mounted on the Aft High Angle Control Director. The 285 office was below decks. Its function was to provide range and bearing for the 4 inch AA fire control.

Type 285. Multiple Pom Poms

One set to control each of the port and starboard Pom Pom mountings.

TYPE SG. Surface Warning. IOcm wavelength.

An American set, fitted after joining the 7th. Fleet. Antenna fitted on foremast with its PPI display in the Plotting Office below the bridge, used for both navigation and surface warning.

Type 277.Aircraft Tracking. IOcm wave length. This unit was fitted during a mid year refit in 1945. Antenna was fitted on the foremast, and its office was in a special extension built on the port side of the bridge structure. Its single dish antenna controlled for both bearing and elevation, and this equipment gave the exact location of its target.

As it turned out the war was almost over, we had the Borneo landings to come, and then the dropping of the two Atomic bombs hastened the end, Japan surrendered, and at last it was all over.

GUNNERY CONTROL.

The gunnery control Radar sets were combined in an integrated system, they all operated at the same frequency, about 600 megacycles. Power came from a large motor generator with a 500 cycle 180 volt output, to avoid interference there was a phase difference between the power supplied to each set.

Type 91 Jamming Transmitter

Radar Counter Measures were fitted in *Shropshire* and consisted of multi band receivers and a Type 91 jamming transmitter.

NOTES

I am beholden for the technical information to Lieutenant (P) R. Slayter RANVR, who supplied it to the Cruisers' Association.

During my time in her, *Shropshire's* Navigating Officer was Commander J. S. Mesley RAN, and her Gunnery Officer was Lieutenant Commander W. S. Bracegirdle DSC** RAN.

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HMAS Culgoa

By Desmond D. Miller. Commodore RAN Retired

My first ship was HMAS *Warrego*. Her only Radar set was a 272 . *Warrego* was in refit. It was Christmas leave period and I was in her for only 2 months.

From *Warrego* I went to *Culgoa*. She was fitted with 276, 286 and 285. The 276/286 office was at the foot of the mainmast, no doubt to enable the shortest straightest aerial feeder runs. The 276 PPI on the bridge was mounted vertically. To gain access to its innards one had to lift it clean off its metal case, and ideally the maintainer needed to be 7 feet tall, of powerful build, in order to avoid serious back damage. The magnetron was spark gap modulated, the moving part of the spark gap mechanism being fixed to the armature of a motor-generator. The spark gap was adjusted by moving the whole motor mounting frame – a fairly clumsy arrangement. In my experience, the 276 was a fairly reliable beast but apart from the Navigator, other bridge officers did not seem to be too interested.

The 286 was a poor performer, mainly because of the slow rotation of the antenna which was controlled by a modified Asdic controller. On the few occasions when we had formal exercises, the "enemy" aircraft came in low and fast, and I don't recall ever detecting them. Aircraft at a distance and some height could be detected. It was also effective at detecting the tops of distant mountains around the coastline of Japan, much to the satisfaction of our Navigator.

Also fitted in the 276/286 office was a small bulkhead mounted IFF equipment – name unknown. There was no handbook for it, nobody ever asked me to switch it on, and I have no idea whether it worked or not. It had a round opening in the lower front panel labeled "Danger. Explosives". There was nothing in this tube. I assumed it was highly secret in wartime and was to be destroyed if the ship was in danger of falling into enemy hands.

The 285 Transmitter room was in a small space below deck roughly below the Director. There was just enough clear deck space in this compartment to accommodate a stretcher. I thus had a private sleeping space, a luxury certainly but a necessity also as there was not quite enough space in the PO's mess to sleep all the POs borne. The display equipment was in a small low space immediately below the Director. Fitted to the top of the Director were 6 Yagi (fishbone) aerials in a horizontal row with a curved metal concave reflector. Transmitter energy was produced by 2 valves, possibly NT99s, joined base to base and mounted vertically at the centre of a cylinder, height about 60 centimetres and diameter about 40 centimetres. It was highly polished and reflective inside - it may have been silver plated. Our instructor at *Watson* told us that you could cook and egg inside that cylinder, but he did not recommend that we try it, because "If you open the access panel and the safety interlocks do not work, it will fry your eyeballs". An early microwave oven?

I encountered an interesting problem with the 285. No matter what I did, the maximum ranges never reached the 'book' figures. I sought the advice of one of the Chiefs at the Port Radar workshop. He accompanied me to the ship and we climbed to the top of the Director. He took a quick look at the director dipoles of the 6 Yagi antennae, told me to undo the middle two, turn them upside down and retighten them. Engraved into the insulating block of the dipoles was its pattern number. He explained that they had to be all up or all down, otherwise the shape of the transmitted beam was distorted. Problem solved in about 5 minutes. *Culgoa* was then about 4 years old. I wonder how many of the 285 Yagis had been improperly installed, and perhaps never corrected.

Thinking back to that time in Culgoa, it seems to me that there was still a deal of scepticism about the reliability of Radar. The 286 was a poor performer as a detector of hostile aircraft. In the use of the 285 gunnery Radar, the few exercises we did were always in the day time and the Gunnery PO in the Director seemed always to produce ranges and bearings which satisfied the Warrant Gunner in the Transmitting Station below decks. As mentioned above only the Navigator seemed to be really interested in what Radar could do to assist him in his duties.

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HMAS Hobart

By Gerald E York. Lt Cdr RAN (Ret'd)

I served in HMAS *Hobart* for all of 1947 during her last trip with BCOF in Japan. This included a visit to Shanghai shortly before Chairman Mao arrived at the end of his "Long March". Other Radar mechanics on board with me were John (Bash) Harrell, ex PO Tel and Basil Richards. Kevin Duffy joined on our return from Japan in September. Lofty Waugh, ex PO RM was the Radar Officer and had just been commissioned as a WO (thin striper). Lofty joined the same time as I joined when he took over from Col Stewart. I left *Hobart* on decommissioning 12 December 1947 when Dick Withers and "Slim" Somervelle joined to complete the decommissioning phase and refit. On completion of the refit *Hobart* went into mothballs for several years before going to Japan for scrapping. In fact I was in HMAS *Melbourne* in Kobe when she arrived in Osaka to be scrapped. That was 1959 I think.

When *Hobart* was at sea, 2 RMs used to sleep in the 281 compartment, one in front of the Tx and the other <u>inside</u> the Tx next to the output bottles (See editor's note).

Hobart had the following Radars:

<u>281 AEW.</u> The transmitter was installed in its own hut on the upper deck midships between the main and foremasts. The antenna was mounted at the top of the mainmast. This was a number of stacked dipoles which gave a range of 200 plus nautical miles. The low frequency of 180 Mcs and antenna height gave it this excellent range.

<u>277</u> combined surface and air warning. This had a parabolic reflector half way up the main mast. Its operating frequency was 3,000 Mcs, wavelength 10 cm. Its capability was aircraft detection (at height) 100 miles and large ships 50 miles.

<u>SG (Sugar George).</u> US design. Operated at 3,000 Mcs. Antenna mounted on top of the main mast just below the 293 antenna. PPI was mounted on the bridge. Navigation capability was up to 50 miles.

<u>285.</u> There were 3 of these for the 4" directors and 4" gun control. The Yagi antennas and transmitter were tuned to 450 Mcs. The "A" scan displays were mounted in the Directors.

<u>282.</u> There were 4 of these. For gun control of the Bofors and Oerlikons. They used Yagi antennas. The "A" scan displays were mounted in the Tx/Rx compartment on the main deck midships waist.

As well, *Hobart* had IFF and LORAN.

Editor's note: All Radar transmitters delivered high power electromagnetic transmissions when operational, these transmissions coming from the Radar set's power output valves, colloquially referred to as the bottles.

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HMAS Murchison

By George Holland HO PO RM

I commissioned HMAS *Hawkesbury* (River Class Frigate) in 1944 and served on her until mid 1946. I refer only to that experience.

We had an ex RN surface Radar E 271. Our aircraft warning set was an A 286.

The E271 was our sole gunnery range finder. The Axis had control of most of the world's optical lens manufacturers so we were without an optical rangefinder. Calibration of the E271 was effected via a screwdriver potentiometer which broadened or narrowed the single green trace on a 6 inch CR tube. During navigation trials, and often at sea, the set could be calibrated using known range objects. During gunnery trials it became a subject of controversy between the gunnery officer and the Radar mechanic, the operators would observe the fall of shot on the screen and shout out the number of yards under or over the target the shot had fallen. The big problem with the E271 was that the impact of the forward gun firing would put the set off the air completely. The early germanium diode as the detector was the first cause but later we had mechanical problems with magnetrons and rectifiers. The magnetron was in a box directly underneath the dish, all contained within the housing above the Radar cabin. The whole assembly was rotated by hand over 365 degrees then wound back. The operator read the bearing from an engraved metal ring on the connecting shaft. This made it very hard to keep track of a vessel following astern. Power cables to the transmitter and coaxial cables from the receiver were constantly swept around and back. The early British 70 ohm coaxial cable was anything but flexible and several temporary repairs had to be executed at sea in the cramped space of the Radar dome by cutting and re soldering the inner conductor and linking the outer braids with a section of a tobacco tin after carefully ironing the polythene dielectric with the hot soldering iron. The Americans only had 50 ohm cable but it worked and was more flexible so gradually I replaced all.

Then as we entered the tropics, the UK designed gear could not handle the moisture. Instead of half inch thick laminated bakelite insulation they had substituted two thicknesses of quarter inch and before long 10kv was arcing out of sight inside the panel. That took a lot of finding. I had to rig festoon carbon filament lamps inside the set to keep it dry.

For all of this we had Radar, we could monitor 70 ships in a convoy under blackout conditions. We could correct the fall of shot and maintain amazing accuracy of gunfire in surface combat. We could range on low surface reefs and land masses and we could locate a periscope at 2000 yards. Over a very short period of time the British had developed wave guide technology, the magnetron – albeit with some help from the Japanese hi permeability alloy Alnico, and microwave dish technology, all of which gave our side the advantage of working in the ultra high frequency spectrum.

Our aircraft warning Radar the A286 was a great achievement for Australian industry. All know of the rotating gramophone needles providing the transmitting pulse via the AV11 an all Australian valve designed and built by AWV the AWA valve company, the huge bedstead antenna built in the NSW Railway Workshops and set atop the mainmast. Those sets gave wonderful service.

Memories

By Bob Linton. HO PO RM

My first contact with a Radar set was with A286P at what was to become HMAS *Watson* early in 1943. This set was originally designed to be fitted to aircraft, and had a Yagi antenna. When adapted for ship-borne use in Australian Corvettes, it had a bedstead antenna . This was controlled by an A/S control unit with "M" type transmission. Two operators were situated in the Radar office. One operator reported echoes by use of sound powered telephones or voice pipe to the officer of the watch on the bridge. Such echoes appeared on an "A" scope which was calibrated in thousands of yards, and indicated land (fixed echoes) or aircraft (moving echoes). The other operator kept a log of these reports, and as well, at the beginning of each watch kept a log of the various meter readings such as local oscillator current, crystal current, and transmitter current. These readings could prove useful to the Radio Mechanic if the set broke down. The power supply was adopted from the aircraft alternator of 180 volts 1000 cycles. This alternator was driven by a 220 volts DC motor (standard ship supply). The complete motor alternator assembly was fitted in one of the seamen's mess decks.

The equipment was fairly reliable, providing it was left in a standby position when not being operated. (See editor's footnote 1). Most problems were "M" type transmitter problems up in the antenna. This is where I was introduced to crocus paper and carbon tetra chloride. (See editor's footnote 2). Test equipment was primitive consisting of a locally made "University" brand multimeter, plus a PMG made cathode ray oscilloscope (CRO) which had a power supply unit one could barely lift, and a "Wee Megger".

At a later date, this A286P was updated to an A286Q with increased power output using "Micro Dog" transmitting valves. The modulator was a spark modulator, quite a sizeable unit, manufactured by H.M.V. (or possibly AWA) in Sydney.

Another set manufactured in Sydney, by AWA Australia, was quite unique in many respects. This was the A276. One of the two engineers responsible for its design and manufacture was named Richardson. The prototype set was installed in lieu of an A271 aboard HMAS *Yandra. Yandra* was despatched to Milne Bay for special duties, and the return journey provided an excellent opportunity to carry out sea trials of the A276. Both the Radar Engineer Lieutenant Bill Boswell and myself assessed its performance and recommended some modifications for production models.

Once again spark modulation was used instead of thyratrons. This was done by attaching 10 tungsten electrodes to the shaft of the motor alternator set in the base of the transmitter cabinet, and one electrode to the assembly frame. The fixed electrode was electrically connected to the magnetron. Each time a moving electrode passed the fixed electrode the pulse line was discharged to the magnetron. As the alternator was 50 cycles and as there were 10 moving electrodes, a pulse repetition frequency (prf) of 500 could be achieved. That is, the A276 Radar would transmit a high power short duration pulse 500 times per second.

The antenna was a parabolic reflector fed by a waveguide horn at the focus. The reflector was made of marine plywood faced with metal, and all housed in a marine plywood lantern fitted to the foremast.

The control of this antenna was another unusual system. It had a motor generator which had various outputs to rotate the array at 5 rpm, 10 rpm and 20 rpm. It also had hand control plus a sector control which was used to sweep backwards and forwards over an echo. Above the "A" scope was a PPI, with another PPI on the bridge.

One interesting feature of manufacture was the modular construction used. For this reason servicing became quite simple by exchanging a faulty unit with a serviceable one, and this meant minimum downtime, especially on the bridge PPI

One of the first production models of the A276 was fitted to HMAS *Glenelg* where I had the job of setting to work in Williamstown dockyard and doing trials on the voyage to Sydney.

Editor's footnote 1. For equipment to be left in a standby condition meant that the power to the filaments of the thermionic valves was switched on permanently, but the High Tension (HT) was switched off. It was a characteristic of thermionic valves that for longer life and more reliable operation, it was best to delay applying the HT for up to 4 or 5 minutes after applying the power to the valve filaments.

Editor's footnote 2. Crocus paper was a very fine abrasive paper, and carbon tetra chloride (CTC) was a universal cleaning liquid. Both were used to clean build up of sea salt, grime, grease, oxidation on electrical contacts.

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Reflections

By Bill Robertson Ch RE RAN

Commencing late 1945, I did my initial training at F.N.D. (HMAS *Cerberus*) as an Ordinary Seaman, then carried on to the Gunnery School where I qualified as a Radar Control Rating (Third Class). Later I completed another Gunnery School course, complete with the dreaded commando section at the Hann's Inlet Rifle Range. This was followed by the Radar training at H.M.A.S. *Watson*, where we were introduced to mainly Type 285, Type 282, and the Operator's control panels for same, namely Panel L24 for 285, and L22 for 282.

Type 285 and Type 282 had identical Transmitters and Receivers. The main difference was in their Aerial arrays. 285 had five "Pig-Trough" reflectors mounted side by side with two Yagi arrays side by side in each reflector. Each Yagi consisted of one driven dipole and six or seven director dipoles in front. Type 282 had only three Pig-Trough reflectors as it was mounted on a smaller director tower. The signal to and from the driven elements passed through a "beam splitter" arrangement which was motor driven and incorporated a "Maltese Cross" mechanism which gave a small phase shift to the centre dipole cluster. This shifted the beam slightly from side to side, so that only a target which was in the very narrow overlap area of the two transmitted lobes would return equal strength signals from each lobe.

The C.R.T. "A" scan in front of the operator had a small shift applied to it which shifted the displayed echo from the right lobe to the right on the display so the echoes appeared side by side with a slight overlap. The two echoes from the same target then gave the operator the clue of which way the aerial had to be turned to line up the target to within half a degree of the centreline of the aerial. The rule was, train the Director (on which the Aerial was mounted) toward the weakest echo. The "A" Scan was an Admiralty pattern watertight rectangular box designed, so I believe, to take a direct hit from a 15 inch shell, and was heavier than I care to remember. The A scan was of course painted blue, and was mounted in the director tower immediately in front of the Trainer, positioned so it was almost impossible to access for servicing.

The Trainer knew which of the echoes on his screen was the one he was supposed to be concentrating on because the operator of the L24 / L22 panel in the Gunnery Control Centre had positioned a strobe over the echo on his screen (from which he was passing range of target information to the guns) and this also brightened the echo at that range on the trainer's display.
A well trained operator could also monitor the splashes from the shells which missed the target (most of them!) and call the "fall of shot" to the Gunnery Officer, as he could clearly see if they were 'over', 'short', 'left', or 'right' .

After a practical course on H.M.A.S. *Murchison* I became a second class RC rating, crossed guns on right arm and all! That was when I saw the light, and shortly afterward I was on my way to H.M.A.S *Torrens* to join the exalted ranks of the R.A.N. Radio Mechanics. On completion of training at "*Torrens*" it was back to "*Watson*" for me. There I was introduced to the mysteries of A276, A286, 285 with which I had some previous non technical experience, Air warning Type 79 and 281, Type 277, and Type 293. We also covered Loran and a 10 cm Radar jamming device which I am pleased to say I never saw again.

At the end of that course I was posted to H.M.A.S. *Shoalhaven*, a River class Frigate, sister ship to *Murchison*, so I had a pretty good idea of what Radar I would find aboard. These were:

Air	Warning	A286
Surface	Warning	A276
Gunnery	Control	285
IFF	242	
A286	A scan display only.	
A276	A scan display and AWA PPI in Radar Office	
	Remote AWA PPI on the Bridge	
	Admiralty type PPI in Operations room	
285	A scan in Radar Office	
	L 24 Panel in Transmitting Station (A scan)	
	A scan in Director Control Tower.	

Two years later nothing had changed except that we had replaced the A scan in the director control tower with a much lighter unit which fitted over the Trainer's binoculars and allowed a 1 inch A scan to be viewed through the right lens when required.

One of the problems with Type 285 was with moisture finding its way into the beam-switching unit and the inch diameter cables, some rigid lead covered, some flexible, which fitted into the device. Regular insulation tests gave warning when these cables had to be removed and dried. The unit itself more often than not also had to be dried out. When all was dry the whole lot had to be re-assembled, the connecting glands packed with lead wool, and tightened up. My offsider, Bill Grant and I were nearly finished this operation one day when it started to rain. To save a couple of day's hard work I sent Bill down to the Sickbay to see the Sickbay Attendant for a handful of condoms which we placed over the ends of the cables and over the connecting glands. About an hour later the Captain sent for me to report to him on the bridge. Pointing to our recently fitted protective coatings he asked me if what he was pointing at was what he thought it was. I explained the situation and emphasised that this was a short term measure which had proved highly effective in keeping everything bone dry. His reply was that our initiative was highly commendable, but as we were entering harbour at first light the following morning I had better start praying for the rain to cease so that we could finish the job, as if he found things looking the same the next morning he would personally place the offending objects where the sun would never shine on them again. I assured him that the message had been received loud and clear. Never had two R.E.s worked so fast when the rain stopped.

Back to "Watson" for an extended stay. I think it was one week! Then it was H.M.A.S. *Hobart*. *Hobart* had one Type 285, one Type 284, must have been six Type 282, one 277, one 293, one 281 and a brace of IFFs. At one time the 284 was due to be replaced by 274. The gigantic parabolic cheese type 10 cm antenna arrived, but that is as far as it got. The antenna was never fitted to the director, and as far as I can remember the electronics never materialised.

All the equipment and displays were standard Admiralty pattern. The one unusual item was in the plotting room. This was a Skiatron. This was a PPI with a high intensity tube which painted echoes a violet colour. The picture on the tube face was projected onto a plotting table from below, via a front silvered mirror, enabling plots to be made directly on the table. I have good reason to remember some of the gear on Hobart as eventually I wrote out the return notes Form AS 331 for every single item on the Electrical Officer's Establishment list and returned the lot to Leichhardt Stores.

By now it was time for another trip to "*Watson*" for a Radar to W/T conversion course. This was to bring us uneducated Radar types into the world of wireless telegraphy. Who the "powers that be" thought had been servicing all the W/T gear on the ships we had been on still leaves me wondering.
We were also brought up to date on Radar type 960 and a few other things. Now that 1 was "full bottle" on all the latest equipment I was posted to a ship where all this new knowledge could be put to good use, H.M.A.S. *Cowra*.

Cowra was a minesweeper, fitted with A276 and nothing much else. I think the radio gear was left over from World War 1. To add insult to injury the ship had been paid off a couple of years before and had been in a state of preservation..... or rather it SHOULD have been in a state of preservation! In truth it was in a state! Some dingbat who shall remain anonymous had used trays of Calcium Chlorate in lieu of Silica Gel to dehumidify the sealed Radio and Radar offices.

Anything which was made of copper and was not plated in some way had stalactites of green corrosion hanging off it. This made tuning the old AWA W/T Transmitter an interesting experience. Strangely the Radar gear was not badly affected. I eventually stripped the AT13C HF Transmitter down completely whilst in dry dock at Williamstown and had every piece of metal in it silver-plated. After that all was well! Our 500 kHz emergency transmitter incidentally was of the spark-gap type, and the emergency receiver was a crystal set! After twelve months on "*COWRA"* I was transferred to "*BATAAN*", one of the three TRIBAL class destroyers built at Cockatoo Docks in Sydney Harbour.

BATAAN was not fitted with the most modern Radar either! The surface warning Radar was an American set S.G. (SUGAR GEORGE). The Long range warning set was S.C. (SUGAR CHARLIE). There was also an I.F.F. set type B.N.. S.G. had an A scan in the Radar Office. This was later supplemented by a PPI display (which I wired up as a "HOT SPARE" quite illegally), as the Display unit on the open Bridge tended to become temperamental when salt water leaked in through the top panel and dribbled over the components. The approach to repairing this particular piece of electronics was somewhat unusual. When the unit was removed from its housing and taken below, still with salt water dripping from it, it was taken directly to the P.O.'s bathroom where it was placed under a warm shower and thoroughly rinsed out to remove any salt. After a couple of days in the Radar office to dry out it usually worked when switched on without any problems other than the odd resistor burning out once in a while. The thought of what this might be doing to the bearings in the deflection coil assembly worried me for a while until I discovered that the bearings were made of GLASS. I had not seen this before nor have I seen it since. It certainly overcame the strange effect caused when steel deflection coil bearings became magnetised and caused echoes to jitter about on the display as the trace rotated.

S.G. also had a PPI in the Operations Room. S.C had a larger PPI in the Operations room and must have had an A scan somewhere near the receiver which was in an annex off the Ops room but I have no recollection of it whatever. The BN interrogator/ IFF was also in the annex.

The Type 285 was in the Radar office with the SUGAR GEORGE. There was an A scanning in the Office, an L24 panel in the T.S. and an A scan in the Director control tower. BATAAN was later refitted with Air warning type 293 in lieu of S.C. and a Commercial 3cm surface warning set in lieu of S.G.

On sea trials following this refit we had an interesting experience with a complete failure of all the new equipment. We had carried out an emergency full-astern exercise with a following breeze.
When trouble shooting we found that there were multiple earths on cables which ran up the aft end of the lattice mast. A post-mortem on these cables showed that the heat from the exhaust gases from the forward funnel had melted the polythene insulation inside the co-axial cables, the heat had caused the inner conductor to expand and to contact the outer conductor causing the short-circuit. The polythene had then set when it cooled leaving the conductors in this shorted state.
We had a quick trip to Williamstown dockyard to have all the affected cables renewed and an asbestos deflector plate fitted to the cable trays.

I encountered one most peculiar problem with 285 on BATAAN, thanks to Garden Island Dockyard. The receiver tuned up pretty well before we left the Island after a minor refit. There were echoes every where from the land, and it was not until we cleared the heads that I ventured up to the Director Control Tower to check the display up there, and found that something was amiss.

I trained the aerial on a passing ship and received no echo! It was some time before I found that a very good echo of the passing ship could be obtained by training about 30 degrees either side of it. Quite some time later whilst sitting on top of the Yagi array I noticed that the Part Number of the dipole assemblies could be seen on the upper part of all except the two central units.
Whilst I had been on leave, unknown to me Dockyard had replaced all the dipole units carefully installing the two central units upside down. This produced two transmitted lobes about 60 degrees apart, each nicely beam-switched As a result it was possible to obtain a very accurate bearing on a target which was actually at 30 degrees to the direction the aerial was pointing. This took about two minutes to rectify but I confess to taking a bit longer to find what was going on.

You may be aware that *BATAAN* and *VENGEANCE* had a collision a couple of hundred nautical miles North West of Darwin whilst we were refueling from the carrier after escorting the Queen (in the

GOTHIC) from Fremantle on her way home after a royal visit. After *BATAAN* managed to disengage from this dingle we were minus a few feet of the bow and the upper-deck superstructure on the Port side had suffered some unsolicited panel-beating. There were also some other strange things which were duly reported in our damage report but quite how significant they were not appreciated at the time. The duty operators of the 293 reported having to shut down the transmitter due to loud arcing and sparking from the waveguide in the Radar room. This was found to be caused by the normal 3/16 inch gap in the waveguide at the transmitter end having closed up. Some force and readjustment of mounting hardware was required to restore the gap. All the main radio aerial leads had to be lowered to the deck and shortened by about a foot or more as they had stretched, and were obviously sagging. The next time we were in dry dock it was found that the keel was twisted. That could not be rectified and *BATAAN* was paid off.

For some strange reason I thought that a draft to my Home Port would be in order but that was not to be. Just so that I would not get to like the feel of dry land Navy Board sent me to HMAS *PLATYPUS* for the ten days I had to wait for HMAS *SYDNEY* to berth.

Sydney was fitted with Type 960 long range Air warning Radar, Two type 277 close range Air warning sets, one forward and one aft of the island. One type 293 and one commercial 3cm surface warning (of the same type fitted to *BATAAN* and whose number I have forgotten) There was also an air branch maintained C.C.A. (Carrier Controlled Approach) Radar mounted aft.

Our own close range Radar proved far more effective for controlling aircraft landings and the CCA set was removed. We had one STAAG mounting Twin 40 mm AA controlled by Radar type 262.
Most of the displays from these Radars were mounted in two adjoining rooms, the names of which escape me for some reason. These rooms were the only part of the ship which had really good air-conditioning. On a couple of occasions in the tropics the air-conditioning broke down. Some bright spark each time opened the outside doors to let some fresh air in. Probably for some selfish reason he thought he should be allowed to breathe. Lovely cold PPI s, lovely humid air, lovely high voltages lots of lovely condensation. Loud bangs, sparks, smoke and a Chief RE with at one time twelve unserviceable PPI s within five minutes. This is not a good feeling.

When *SYDNEY* went into refit to become a troop transport I was sent at last to my Home Port to serve out my last two years. Was I, Like hell I was! It was off to The L school at FND to lecture on Auto Acquisition Fire Control Radar! If you would like to know how Conical Scanning is achieved or how the Radar controls the hydraulics of a STAAG mounting to search for and lock on to a target and track it just ask me. It will take another page or two. Perhaps some other time.

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H.M.A.S. Napier

By Tom Chapman. HO PO RM

Early during WW2, eight "N" class destroyers were built in the UK, and 5 of these were manned mainly by R.A.N. personnel. Most of these ships were fitted with surface warning and gun fire control Radars. Photographs of the time show a mast top aerial and a 285 type aerial above the visual rangefinder.

In the 1944-45 period, *Napier* had a type 271 Radar fitted. This was a 10 centimetre surface warning Radar and it replaced the visual rangefinder. The Radar office was abaft the director and had a timber and perspex dome above. This dome housed two aerials and the transmitter. Aerial rotation was via a drive shaft manually controlled by the Radar operator through 360 degrees with a slight overlap astern. The display was an "A" scan, and this together with two operators completely filled the Radar office. Details of echos were passed to the bridge by voicepipe or by phone. A small office two decks below housed the L17 panel accurate range measurer. From here, ranges were passed verbally to the Gunners Mate by phone for the purpose of fire control.

As well in this period 1944-45, *Napier* had a type 291 combined surface and air warning Radar. The antenna was at the top of the foremast, and was hand driven by a Bowden cable under the control of the Radar operator. Display was an "A" scope and was located with the remainder of the 291

equipment in an office off the flag deck. This set was linked to the L17 if accurate ranges were needed. Contact with the bridge was all verbal by voicepipe or phone. In this office off the flag deck was also located the IFF type 253 and the controls for the Radar power supplies. These supplies were two 180 volt 500 cps generators in “A” boiler room.

During September 1944 the type 271 Radar was replaced by a new and more efficient type 271. The interrogator 253 antenna rotated with the 271 antenna. A PPI display was installed in the Plot room, but had limited value as the 271 aerial was not continuously rotating.

The US built Radar type SG (Sugar George) was fitted early in 1945. Its power supply and some of SG’s units were fitted below the Pom Pom mounting. The remainder of the displays and antenna controls were fitted in the Plot room. The antenna was fitted high on the foremast. Sweeps could be all round or sector at various speeds, a big improvement on the old hand drives. There was also a small PPI installed on the bridge.

Napier was flotilla leader, and carried two Radio Mechanics. Presumably the “spare” RM would be transferred to a ship in need of service or whose own RM had come to grief.

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Radar Equipment HMAS *Shropshire*

By Lieut (Sp) R. Slatyer R.A.N.V.R. Radar Technical Officer, HMAS *Shropshire* October 1943 to January 1946

When *“Shropshire”* was being prepared in England for handing over to the R.A.N. in 1942/43, she was fitted out with a full complement of the current R.N. equipment. The following list of equipment in numerical order of type number includes other equipment installed later.

Type 273. SURFACE WARNING. Wavelength 10 cm (Frequency 3,000 Megacycles). Located just forward of the after control position. Antenna gyrostabilised, located in a “lantern” structure directly on top of office. Also connected to an accurate range display panel in the T.S.

Type 277. AIRCRAFT TRACKING. Wavelength 10 cm. fitted during a refit in mid 1945. Antenna on foremast. Office in new extension on port side of bridge structure. Single “dish” antenna controlled for both elevation and bearing enabled this equipment to provide information on the exact location of an aircraft.

Type 281. AIR WARNING. Frequency 90 megacycles. Transmitting antenna on mainmast with transmitter in office at base of the mast. Receiving antenna on foremast with receiving office on flag deck at base of mast. Antennas rotated in synchronism. The 281 was undoubtedly Shropshire’s most important radar unit! More on this later.

Type 282. For control of multiple pom poms, one set for port and one for starboard.

Type 283. AUTO BARRAGE UNITS. One for each turret. Each set had a control station with display unit on the upper deck. Main office below decks. The purpose of these sets was to enable efficient use of the main armament against dive bombers. We found them quite useful when there were Kamikazes around.

Each of these sets was equipped with a small fire control device – a sort of mechanical computer. When the main armament guns were loaded with shells fitted with a time fuse, generally set for a different time in each barrel, this device would calculate the correct time and fire the gun so that the point at which the shell exploded was the point at which the aircraft would be if it continued on the same course and speed.

Type 284. GUNNERY CONTROL MAIN ARMAMENT. Antenna mounted on the main armament director. Office below decks, accurate range display panel in the TS provided range and bearing for main armament fire control.

Type 285. 4 INCH ANTI-AIRCRAFT GUNS Antenna mounted on after director – high angle control position. Office below decks. Provided range and bearing for anti-aircraft fire control.

Power supplies to all of the gunnery control radars were combined in an integrated system. All sets operated at the same frequency, around 600 Megacycles. Power was supplied from a large motor alternator set with output 180 volts at 500 cycles, which was their pulse repetition frequency, and interference was avoided by having a phase difference between the power supplied to each set

Type SG. An American unit of 10 cm wavelength fitted soon after we joined the 7th Fleet. Antenna on foremast, PPI display in plot below bridge. Used for surface navigation as well as surface warning.

RADAR COUNTER MEASURES. Equipment consisted of multi-band receivers and a type 91 jamming transmitter.

CAPABILITY REPORT

During service in the New Guinea and Philippines campaigns HMAS *Shropshire* achieved a reputation for, among other things, the efficiency of reporting of aircraft movements (Editor's note, see appendix below). I will attempt to explain, briefly, how I consider this was achieved.

This efficiency was due to a combination of:-

The nature of the equipment
Maintenance and tuning
Skill of the operators
Efficiency of the plotting office
Team work

Nature of the equipment. The primary air warning radar was Type 281. This was a rugged piece of equipment built in the style of the R.N. long range W/T sets. The output stage of the transmitter gave an impression of power with quartz "tubes" about 12 cm. in diameter and 40 cm. long.

The transmitting antenna was on the mainmast and the receiving antennas on the foremast. They were broadside style arrays with timber frame, ceramic insulators, and aluminum dipoles. The feeder for the transmitter was of twin wires held apart by plastic insulators. The receiver feeder was "Protean"

On the flag deck at the base of the foremast was the receiving office. In this were all components of the receiver, including the display and the controller for rotation of the antennas as well as the telephones.

Maintenance and tuning. Because of wartime shortages in England, the materials used for the construction of exposed parts were not always as durable as they could have been. This factor, added to the severity of the tropical conditions in which we were operating, resulted in the need for frequent maintenance work to maintain peak performance. Careful attention was given to this, which included much masthead work, varnishing woodwork and cleaning insulators – even on one occasion, at night in the tail end of a typhoon, to wash off salt spray which was causing sparking while the ship was darkened.

As regards tuning, one feature of the 281 was that most units where tuning was was critical were designed so that they could be tuned to maximise performance. This is different from many other radars where such units are preset and changes over time can adversely affect performance.

Skill of the operators. The display was a cathode ray tube about 15 cm in diameter, known as an "A" scan. (Editors note: See description of "A" scan in the chapter "Radar Basics"). The operator had control of the rotation of the antennas, which rotated in synchronism, and he would adjust the angle of the antennas relative to the fore and aft line of the ship to maximise the "pip" and find the bearing of the aircraft. Some refinements in technique would provide an estimate of the height of the aircraft.

This information would be telephoned to the Plotting Office.

To accurately maintain reports on a number of aircraft on this type of equipment required a great deal of skill on the part of the operator. There would be two operators on watch and they would relieve each other from time to time. *Shropshire* was fortunate in having a number of men with this ability.

Efficiency of the Plotting Office. As well as receiving the reports of aircraft detected by the ship's radar this office was in communication with other ships in the fleet, friendly aircraft and shore bases. Reports of aircraft positions were plotted on a large board. At times a great deal of information was processed and personnel became very skilled. The officer in charge was of a temperament well suited to his position. *Shropshire's* callsign was "PORTHOLE" and this name became famous as a source of information on warnings of hostile aircraft.

Team work. As with all operations in a fighting ship the overall efficiency depended on team work. In *Shropshire* there had been very few changes in personnel and all members of the ship's company had learnt to work together.

This undoubtedly was an important factor in all operations. Perhaps the reports that she was a "Lucky Ship" also had some validity.

Appendix

Extract from "Royal Australian Navy 1942 – 1945" by G Herman Gill. Quote from Leyte Nov – Dec 1944 page 536 "*The American destroyer Ammen referred to the superb Radar telling performed so steadily and reliably by the Shropshire during the operations against the enemy just completed. The information provided by Porthole (Shropshire's communication designation) was of inestimable value in maintaining the Ammen alert and ready to deal with the Nips at all times"*

Further, in a letter to Captain Nicholls, Admiral Weyler remarked that "*Commander Task Group 77.1 concurs that Shropshire's performance in radar telling was outstanding and takes this opportunity to congratulate her Commanding Officer, and all officers and men who contributed thereto. As a matter of fact Shropshire's excellent performance in subject matter has heretofore been attested in reports submitted to Superior Command.*

As well, pages 182 and 183 of Stan Nicholls book "HMAS *Shropshire*", published by the Naval Historical Society of Australia December 1989 (ISBN 0 958 7456 2) quotes a number of high commendatory remarks about *Shropshire's* radar efficiency, made by senior officers of the USN, & RN.

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HMAS Sydney

Written by Cherub Log from material provided by PO RE Gordon Wood

Gordon Wood was one of the first Radio Mechanics to graduate from the Adelaide School of Mines RAN training program in August 1946. Following advanced training at HMAS *Watson,* Gordon later was a student at HMS *Collingwood* and HMS *Mercury* in the UK for all of May and June 1947, training to be part of the crew of Australia's aircraft carrier acquisition, HMAS *Sydney*. It was here he studied Radar types 262, 276, 277, 293Q and 960, as well as type 242M Interrogator. What follows are some verbatim extracts taken from Gordon's hand written course notes.

The A276 has been designed as a high power surface and air warning set operating on the "S" band (3,000 Mcs). It operates from 220 volt DC mains and is complete with its own motor alternator unit which supplies 180 volts 500 cycles. Peak power is 400 Kw, PRF is 500 cps, pulse length is 1.0 µsecond. The display equipment is 1 "A" scan and up to 3 PPIs. The "A" scan ranges are 35,000 and 140,000 yards.

The transmitter employs a magnetron type AV16 as Tx valve and is provided with a waveguide output. The aerial consists of a sliced parabaloid fitted with waveguide horn feed. The aerial is capable of 3 modes of operation. One is continuous rotation in either direction at speeds of up to 10 rpm. A second is manual training with gyro stabilisation in azimuth of the true bearing. The third is a sector of

variable width between approximately 10º and 80º with gyro stabilisation in azimuth of the mean bearing of the sector.

The Type AUJ aerial has narrow horizontal beam and moderately wide vertical beam. Hand driven in both directions or continuous in one direction. Stabilised in azimuth, i.e. when rotating it does so at constant angular speed relative to the space around the ship regardless of the ship turning or stopping, or if stopped on a particular bearing it will be kept on that compass bearing, Because of the moderately wide vertical beam, vertical stabilisation is not necessary.

The 293. Aerial type AUR. Similar to 276 and designed as target indicator to detect high flying aircraft. Efficiency in horizontal plane not as good as 276.

The 277. Aerial type AUK. Narrow beam in both planes and moves vertically as well as in azimuth. Can be rotated at power at variable speeds in either direction. Stabilised in azimuth and vertical plane enabling angle of sight of aircraft to be found using HPI or by controlling the vertical movement for maximum echo on the normal scan and reading aerial elevation. An interrogator 242 forms part of the equipment. There are 3 types of indicators, the PPI, HPI and TPI. The TPI is a normal type of PPI but has cursors projected optically on to the screen so that target bearings may be transmitted away to gun control positions or other Radar sets.

The Range Transmission Unit (RTU52) is fitted and enables the range of an echo indicated on the normal scan to be passed to various parts of the ship by lining up a bright spot on the scan with the echo.

The Sector Selector Unit and panel can observe on the normal scan all echos in a chosen arc of bearing whilst the aerial rotates continuously. Echos brighten when the aerial passes through the bearing.

The 293Q. 10 cms. Identical to the 277Q except for aerial and aerial control unit. This has a cheese type aerial tilted to give close range surface cover and air cover up to 35,000 feet. Used as target indicator set but provides all round low and medium air and surface warning when 277 is height finding. 293Q differs from 293P in having a larger cheese aerial.

277Q 10 cms. Warning of low flying and surface craft. Also accurate height finding.

The 262 was designed for control of close range weapons, and supercedes the 282. The STAGG (Stabilised Tachometric Anti Aircraft Guns) was the first type of 262 and consists of Bofors in a twin 40 mm mounting having the Radar set mounted in cubicles on the gun platform. CRBFD (Close Range Blind Fire Detector) is similar to STAGG but having its Radar set in cubicles and the tach box mounted in a director with a completely separate gun platform. The director contains a dome analyser (dummy gun). Present policy is to control one Bofors mounting with one director

Frequency is 10,000 Mcs. PRF is 1,500.Pulse length is 0.5µsecond. Maximum range to lock on to a twin engine aircraft is 7,000 yards.

To give a feel for the complexity of the 262 circuitry, what follows is a summary list of the major sub assemblies:

Long Tailed Pair. Used mainly as a signal amplifier, the objective being to obtain a balanced output from unbalanced input.
Differential Amplifier. Objective is to obtain high amplification from nay slight difference in the input potential to the grids.
Resistance Modulator. Purpose is to produce an AC voltage of fixed frequency and whose amplitude depends on the amplitude of applied DC.
Miller Retainer, Miller Transitron, Resonant Charger, Range Saw tooth Generator, Strobe Firing Flip Flop. These were all special circuits designed to give particular wave forms such as square waves and saw tooth waves.

Some of the special circuits and units were:

Modulator, Triggering Valve, Switching Valve, Head Amplifier with AFC (Automatic Frequency Control), Differential Detector, Radiation Meter, Strobe Amplifier, X.C.O Magslip, T.B.I System, Radial Line Producer, Strobe Positioning Circuits, Strobe Generators, Range Voltage Generator, Signal Measuring Strobe Rectifier, Locking Flip Flop, Suppression Delay Line, Rate Memory Circuit, Magnetic Brake Circuitry, Servo Unit, Limiter Unit, Phase Discriminators

The Rectifier Unit was designed to provide different high tension DC voltages for operation of various units. The initial supply to the rectifier was 80 volts 500 cps, and the DC outputs were +500volts, +300 volts, +200 volts, -150 volts and -2,250 volts.

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Yarra III

The time frame of this story is some 6 years after the arbitrary cut off "history date" of 1955, but it was considered to be of likely interest level to readers.

By Chief RE Ray Brown

HMA Ships *Yarra* and *Parramatt*a were among the first RAN ships to be fitted with the powerful new Dutch made Long Range Air Warning Radar, type LWO 2, when these ships were commissioned in 1961, LWO 2 had an exceptionally large Radar aerial, which was fitted to the very top of the foremast on both ships. This caused the ships to 'roll on wet grass". On later ships, the aerial was installed much lower to improve stability.

With such a powerful Radar, it was not realised what the ramifications would be when we 'let it loose on the unsuspecting populace'. To date there had been no negative or positive feedback from the public about Radar testing and use. This was about to change. Following are some of the complaints received.

* The Gore Hill ABC studios: Radars upsetting the recording facilities
* RAAF: LWO 2 Radars had disrupted one of the RAAF's major exercises when Yarra & Parramatta were operating off the mid northern NSW coast.
* Crew: Scared hell out of sailors when there was terrific noise generated by much arcing and sparking in the waveguide run from the transmitter to the aerial.
* Newspapers: Navy 'death ray' fears. Strange beams of light at night. Budgerigars going crazy, telephones ringing, nosebleeds and spine tingling. Electrical appliances at a Wooloomooloo community centre 'acting strangely'. This story backed up by a soccer star who said Radar testing affected his hi-fi equipment and set off as many as 3 car alarms simultaneously.
* Independent MP Clover Moore used the publicity to champion the cause for those believing in death rays. In a letter to the Defence minister Kim Beazley, Clover Moore stated that the Navy freely emits millions of megawatts of focused pulse-powered radio energy, which slams straight through brickwork of residential building and human tissue. Moore also reported being told by a dockyard employee that when the Radar was tested during the day, data in the Defence Force Credit Union computer was erased. In another letter to Defence minister Beazley, Moore claimed that memories of VCRs, phones and remote control answering machines were being wiped.
* Other complaints included interruption to TV and radio reception, car and indoor alarms being activated.

A Navy spokesman admitted that some Radar transmissions did interfere with some electrical and electronic appliances, and that to minimise inconvenience, test transmissions would be carried out between midnight and dawn, specifically to eliminate interference with Channel 2 ABC transmissions. As well, the dummy load facility was invoked, which almost entirely stopped external transmission.

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R.A.N Aviation Radar

By Cherub Log & "Skip" Distance

The two eras of R.A.N. aircraft in operational use up to the mid 1950s were firstly the Hawker Sea Fury and the Fairey Firefly 5 & 6, both piston engine driven, and secondly the De Haviland Sea Venom Mk 53, and the Fairey Gannet. The Venom was powered by a centrifugal flow turbojet engine. The Gannet had a double Mamba 100 gas turbine engine driving contra-rotating co-axial four bladed propellers. The double Mamba was basically two side-by-side propeller turbine engines, each driving one propeller through independent gear trains. The port engine drove the front propeller. Both engines were necessary to launch this aircraft, but once airborne it could cruise comfortably on one engine only.

The Sea Fury was a single seater fighter aircraft, with no radar fitted. The Firefly was a fighter bomber and carried a crew of two, viz pilot and observer seated in separate cockpits, the observer being astern of the pilot. The observer had control of the AN/APS IV "Ash Bomb" radar. The complete transmitter, receiver and antenna assembly was housed in a nacelle which was fitted to the underside of the aircraft's port mainplane (wing), and which looked like a long range fuel drop tank or a large bomb. Control panel and modified "A" scan display were fitted in the observer's cockpit.

Operating frequency of the "Ash Bomb" was 10,000 Mcs using a cavity magnetron transmitter and klystron local oscillator. Intermediate frequency was 9 Mcs. Maximum range was 100 nautical miles at 10,000 feet altitude. The antenna dish reflector oscillated port to starboard 40 degrees from dead ahead at a rate of one complete sweep every 1.5 seconds. Thus the operator had a continuous 80 degree sweep ahead of the aircraft.

Firefly AS 5 and AS 6 were used to good effect operating from HMAS Sydney during her two Korean War tours. The last Firefly AS 6 was phased out of service in 1955.

The Sea Venom came into service with the R.A.N. in 1955 and was phased out of service in 1963. Unlike the Sea Fury which the Venom replaced, this fighter aircraft carried a crew of two, viz pilot and observer seated side by side. Behind a perspex dome which was the nose of the aircraft the transmitter, receiver and antenna assembly of the air intercept radar type AI 17 (ARI 5807) was fitted. AI 17 operated at 3,000 Mcs. The antenna was a sector sweep dish.

The primary role of the Gannet was anti submarine warfare. The search radar fitted was the AS Mk 19B. This radar operated in the 3 centimetre band (10,000 Mcs), generated from a power klystron. The transmitter, receiver and antenna assembly were fitted in a radome housed beneath the aircraft's belly. When operational, the observer would cause the nacelle to lower some 120 centimetres below the aircraft's fuselage. This would allow unobstructed transmissions and receptions for a full 360 degrees of antenna continuous rotation, or selected sector sweep. For the history of the development of ASV Mk 19B, see the separate article "ASV Mk 19B" by Chris Poole.

The Gannet carried a crew of 3, viz pilot, observer and crewman seated in separate in-line cockpits. Both observer and crewman could operate the Mk 19B radar , each having his own control unit and PPI display

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AI Mk 17 Radar System in Sea Venom FAW Mk 53 RAN Aircraft - Trials and Tribulations

Author: John S. Saywell OAM

Background

The AI Mk 17 Radar was developed as an airborne Radar aircraft installation for fighter aircraft to provide aircrew with target acquisition information under adverse flying conditions, such as cloud, rain or night flying when it was not possible to obtain visual contact with targets, i.e. it was a "blind firing" radar!. The principal targets considered were enemy aircraft.

A succession of Air Intercept Radars had been produced in the United Kingdom for use in RAF & RN fighter aircraft, each new development having better performance & more operating features than the previous version. In the early 1950s, AI Mk 17 Radar was in its design/development phase & this was the Air Intercept Radar chosen by the Royal Australian Navy to be fitted in its new jet fighter aircraft – the Sea Venom FAW Mk 53 for operation from the soon to be acquired angled deck aircraft carrier, HMAS Melbourne, then being built at Barrow-in-Furness, Lancashire, England.

Design Authority

The Design Authority for the AI Mk17 Radar equipment was the Royal Radar Establishment located at Malvern, Worcestershire, England.

Users

Whilst the AI Mk 17 Radar was under development, there emerged two main user groups for the equipment – they were the Royal Air Force & the Royal Australian Navy. The Royal Air Force intended the Radar to be fitted to the first 300 of the Gloster Javelin All Weather Interceptor Fighter Aircraft whilst the Royal Australian Navy was to purchase the AI Mk 17 Radar for all of its 39 Sea Venom FAW Mk 53 Aircraft. Other AI Mk 17 Radars were purchased for operational spares. History ultimately showed that the Royal Air Force only fitted the AI Mk 17 Radar to the first 40 of a total of 436 Gloster Javelin Fighter Aircraft produced, with production having commenced in 1954. Those 40 aircraft were designated as type F(AW) Mk 1

On 23 July, 1951, the Australian Minister for the Navy, Mr William Mahon announced the de Havilland Sea Venom would be ordered for the RAN & the order was subsequently made formal in December, 1951.

The Sea Venom FAW Mk 53 was to be capable of operating in all weather conditions, day or night & so needed Radar equipment to meet this requirement. The design of the RAN's Venom FAW Mk 53s was basically similar to the Royal Navy's Venom FAW Mk 21 with the exception of the Radar equipment. The Royal Navy opted for an American Radar – the AN APS 52 equipment.
At the de Havilland Aircraft Factory at Christchurch, Hampshire, the Royal Navy Sea Venom FAW Mk 21 & the Royal Australian Navy FAW Mk 53 were produced concurrently.

The first RAN Sea Venom FAW Mk 53 aircraft became available for fitting of the AI Mk 17 Radar & various trials in the third quarter of 1954.

Initial Technical Training of RAN Personnel in AI Mk 17 Radar

By authority of J.B. Foley, the then RAN Liaison Officer at Australia House, The Strand, London, in March, 1954 arrangements were completed for Sub-Lt(l) J.G.Somervelle & Radio Electrician (Air) J.S.Saywell to undertake 13 weeks of technical training at the Royal Radar Establishment at Malvern & those manufacturers producing the various units comprising the total Radar system.

Sub-Lt(L) J.G. Somervelle & Radio Electrician (Air) J.S.Saywell became integrated into the team introducing the AI Mk 17 Radar equipment into service with the RAF & the RAN. There followed liaison with the various manufacturers to head off potential problems with equipment when in service. Some modifications were introduced, at the manufacturing stage, which improved the reliability of the equipment in service.

The Manufacture of the AI Mk 17 Radar.

The AI Mk 17 Radar system was designated as ARI 5807, where ARI = Air Radio Installation. The Radar system was comprised of a number of units of various sizes which had to fit into any available nook or cranny in an already crammed full aircraft. By breaking the installation down into a number of units made it easier to fit the total equipment into the aircraft. Of course, some pieces of equipment by virtue of their functionality had to be located in set locations, e.g. the Radar antenna, the Observer/Navigator's Radar indicator & the Pilot's Radar-Ranging Gyro Gun sight.
A number of manufacturers were involved in producing the various units comprising the AI Mk 17 Radar System:-

- Metropolitan-Vickers Electrical Co. Ltd., Manchester manufactured the Scanning Unit 122; Servo Amplifier A3706 & the Modulator Unit 301.

- E.M.I.E.D. Ltd, Feltham & E.M.I.Factories Ltd, Wembley manufactured the Transmitter Receiver 3701.
- E.K.Cole Ltd, Malmesbury manufactured the Radar Indicator Unit, Type CRT 100 & Control Units Type 900, 901 & 902, Power Unit 901, the Strobe Unit 100 & the Junction Box 389. At the time they were also carrying out development work on a Gating Unit, 10D/18931 & Power Units 910 & 911.
- Heston Aircraft Ltd, Hounslow were responsible for Radome cooling & various connectors & for Ground Running equipment.
- Wayne Kerr Laboratories Ltd, New Malden produced some test equipment, such as the Scanner & Gyro Simulator 40/9 & Test Set X1440.
- Ferguson Radio Ltd, Enfield manufactured the Gating Unit 10D/18931 & Power Units 910 & 911. They were also doing development work on the Power & Cathode Follower Unit X4503 & Cathode Follower Unit X4504 – the latter units were for operating multiple Radar Indicating Units for the training of Navigators.
- G.E.C.Ltd, Union Works, Wembley manufactured the Performance Testing S Band Resonator Type 101.
- S.G. Brown Ltd, Watford manufactured the Gyro Unit Type 2.

AI Mk17 Radar Brief Technical Details & Operational Aspects

- **Function**: Primarily intended to be used for Air Intercept & Blind Firing against enemy aircraft targets. Additionally, had a search function throughout its full antenna sweep range in azimuth & elevation, so, providing surface target information. Limited sector scans of the antenna could be initiated in particular zones of interest when zeroing in on a target. When locking on to a target aircraft the system antenna produced a conical beam which was used to produce target "up", "down" & "left", "right" information relative to the attacking aircraft flight datum. Target range was derived from the radar & in the final phase of the attack, Radar Range information was fed to the Pilot's Radar–Ranging Gyro Gun sight to correct the gun aiming for range of the target. At this stage of the attack, additionally, a radar target indication was also fed to the Pilot's gunfight via a collimator, enabling the Pilot to engage the target under blind firing conditions. The radar was controlled at all times by the Observer/Navigator/Radar Operator located to the right of the Pilot. The Observer/Navigator/Radar Operator had access to all Radar control units & monitored target information on the CRT Indicating Unit Type 100. The antenna pointing position was able to be controlled via a joystick controller on the main control unit.
- **Radar Band** : S Band
- **Type of Radar** : Pulsed power microwave transmitter; TR & Anti TR Cells; superheterodyne receiver with klystron local oscillator & crystal diode detector
- **Peak Power** : 250 kilowatts peak power
- **Pulse Length** : < 1 microsecond
- **Pulse Repetition Frequency** : Variable, depending on mode of Radar operation
- **Antenna** : Parabolic reflector with a rotatable waveguide fed offset dipole with a reflector element which produced a conical beam (3 degrees angle between half power points) when in the final lock–on mode. In the search modes the rotatable antenna feed was locked in position with the dipole element in a vertical polarisation position. The antenna dish was controlled by servo motors & had gyro correction signals applied for stabilisation purposes.

RANSMP at the deHavilland Aircraft Factory.

A Royal Australian Navy Special Maintenance Party (RANSMP) was established at the de Havilland Aircraft Ltd, Christchurch factory to liaise with the Sea Venom FAW Mk53 aircraft manufacturer to head off any potential problems which could arise under actual service conditions. The RANSMP was comprised of a limited number of personnel from a number of disciplines. The Radar & Electrical aspects were covered by Sub Lt (L) J.G.Somervelle & Radio Electrician (Air) J.S.Saywell.
There was also a RNSMP present, at the same time, at de Havilland Aircraft Ltd overseeing the Royal Navy Sea Venom FAW Mk 21 aircraft.

At the de Havilland Aircraft factory, John Saywell had a special monitoring panel built to monitor various parameters of the AI Mk 17 Radar fitted in Sea Venom FAW Mk 53, Serial No., WZ893 during its first test flights The monitor panel was strapped to the Observer's legs, above the knees as

there was no where else for it to be placed conveniently! This was going to place an obstacle for the Observer in the event of a "bailout" being necessary in flight! John Saywell was to be the Observer, until Australia House, London heard of what was happening & an immediate ban was put on John Saywell flying as the Observer, "As too much had been invested in Saywell to lose him!" Australia House insisted on a de Havilland personnel to occupy the seat. It wasn't necessary for him to bail out in flight & the equipment came through with flying colours
During the period that the RANSMP was at the deHavilland Aircraft factory deck landing trials were carried out using Sea Venom FAW Mk 53, Serial No., WZ893 fitted with AI Mk17 Radar. The deck landing trials were carried out over a couple of days on board HMS Bulwark off the English south coast. Members of the RANSMP were embarked on board HMS Bulwark for those trials, Sub Lt (L). J.G Somervelle & Chief Radio Electrician (Air) J.S.Saywell covered the Electrical & Radar disciplines during those trials. Commander (L) G.F.E.Knox RAN, who was normally located at Australia House, London was present for the deck landing trials. The AI Mk 17 Radar equipment was physically & functionally checked after each deck landing. There were no problems found during those trials

Proof Testing of AI Mk 17 Radar at RAF Boscombe Down.

RAF Boscombe Down was an Experimental Aircraft Establishment run by the RAF & the British Ministry of Supply where new aircraft types were put through their paces prior to being introduced into service. Boscombe Down was north of Salisbury & not far distant from Stonehenge.

The "Cold War", between the Western & Eastern Blocs was still running strongly & this was a factor in the new types of aircraft to be sighted at RAF, Boscombe Down in those days!

Sea Venom FAW Mk 53, Serial No., WZ893 arrived at Boscombe Down to be put through its paces & to gain a knowledge of the operational performance of the AI Mk 17 Radar in flight. At this stage we were joined by Lt Commander Gavin Kable RAN who was to be the in flight Observer /Navigator/Radar Operator. The Radar performed well except for ground & sea clutter whilst in flight. This was cured by the use of Radar Absorbent Material (RAM) being fitted to the fibre glass radome which formed the nose of the aircraft. There was some experimentation in arriving at the final pattern of the RAM so that it did not detract from the search performance of the Radar.

"Shooting Trials" using AI Mk17 Radar at 78 Wing RAAF, Takali, Malta G.C.,.
The next phase of proof testing the performance of the AI Mk17 Radar was to operate an aircraft fitted with the Radar intercepting remote controlled target aircraft, firing its guns & evaluating the in flight performance. Those tests were conducted over a period of some weeks in Malta G.C., commencing in the third quarter of 1954.

Getting to Malta G.C. should have been a relative "breeze", but it turned out to be a saga in itself! A Royal Air Force Douglas DC3 (a Dakota) "workhorse" aircraft had been allocated for the purpose of transporting the trials equipment & personnel from RAF Boscombe Down to Takali, Malta G.C. The DC3 had been prior loaded with its extensive content of trials equipment, including spares to support the testbed aircraft. The personnel were located in any available space amongst the freight! It certainly wasn't 1st Class or even Business Class, perhaps it was even below Steerage Class, but, that was the way it was done in those days & no one made any comment about the conditions! Takeoff from Boscombe Down was scheduled for 0600 & this was duly achieved – breakfast was scheduled to be taken at RAF Lyneham from where we would be given clearance to depart for an overseas destination. On takeoff, one wheel came up & the other stayed down & refused to come up. The pilot then tried to drop the wheel which had come up but it refused to go down. The pilot next decided that he would try to shake the wheel that was up to go down; this "shaking" exercise consisted of flying the DC3 as though it were a fighter aircraft with violent moves and steep dives with a vigorous pullout from the dive. Thankfully the pilot kept us informed of what he was doing, but it isn't recommended flying on an empty stomach! The wheel that was "up" stayed where it was throughout all manoeuvres, so finally, the Pilot decided that he had no option except to go in for a crash landing with one wheel up & one wheel down. The next consideration was to use up as much fuel as possible before attempting the landing; this was accomplished after some appreciable time – with a possible breakfast time looking more like lunchtime! With the fuel load being all but depleted it was then into the crash landing phase. On the final approach, the wheel that was up decided to drop down, but lo & behold there was no lock light indicating. Fortunately, the errant wheel was in the lock condition & the landing was completed safely & a late breakfast was enjoyed by those on board. The DC3 was handed over to "maintenance",

with another aircraft being organised to take the Trials Team to Lynham where the DC3 was intended to catch up with the Trials Team. With time marching on & no sign of the DC3 another aircraft was arranged to take the Trials Team to Malta with the DC3 to follow with the Trials Equipment. A stopover was scheduled at the French Air Force Experimental Base, located near Istre in the south of France. Late in the day the RAF aircraft had UHF radio failure & as the final leg of the flight to Malta was to be at night across the Mediterranean Sea, the aircrew of our transport aircraft decided to return to England & left us at the French airbase near Istre to await the arrival of the DC3 – it arrived in due course. However, it was to be more than a week before we finally departed from Istre! That DC3 aircraft had more problems than one could wish for & we were beginning to believe that we were forgotten people! Fortunately in the Ville D' Istre there was an annual festival in progress & the Trials Team joined in the celebrations with gusto becoming almost honorary citizens. Parts for the DC3 were delivered from England & after a successful test flight the Trials Team once more climbed aboard & we headed for Malta. We didn't get far before there was another magneto failure & due to the aircraft loading, height could not be maintained on one engine! It was back to Istre, barely skimming the stone wall at the end of the runway! Then followed more parts flown from England, more test flights & finally another takeoff for Malta, at night. When quite distant from Istre & at height one engine decided it was time to provide some excitement – the "fireworks" appearing from the exhaust were spectacular! But, with one engine malfunctioning we were losing height & various airfields on Mediterranean islands were placed on alert for a potential emergency landing. The faulty engine finally gave up & we continued for Malta losing height. Finally, we arrived over Malta & reached the Takali Airfield with very little height left & when over the runway threshold the remaining engine realised it was time for it to get into the act & promptly failed, causing us to drop like a brick onto the runway! We had arrived – fortunately in one piece! <u>Note</u>: When the trials were completed the RAF sent a four engined Avro York aircraft to Malta to return the Trials Team to England with the return journey being uneventful! At the time of departure from Malta, the DC3 aircraft was still there, unserviceable!

The location selected for the "shooting" tests was at the Takali airfield, Malta G.C. from which the Royal Australian Air Force 78 Wing was then operating, during a "Middle East Crisis". There was, additionally, a squadron of the Royal Auxiliary Air Force temporarily located at Takali conducting exercises with the Australians. The Australians & their English colleagues were operating in de Havilland Vampire fighter aircraft.

The location in Malta G.C. provided a site with reliable weather & a lot of open space over the Mediterranean Sea in which to conduct the shooting/proof testing trials.
For the trials, the AI Mk17 Radar was installed in a Gloster Meteor NF 11 fighter aircraft & had cameras installed to assess the accuracy of the gun's ammunition, with a liberal mix of tracer shells included, against the target aircraft when being operated with radar information fed to the Radar-Ranging Gyro Gun Sight (GGS). In the initial testing phase the guns were deliberately misaligned, to minimise the cost of target aircraft which were French designed remote radio controlled target aircraft. The Gloster Meteor fighter aircraft Pilot was Polish, having been in the Free Polish Air Force operating in Britain during World War 2 – so, together with a sprinkling of British Ministry Of Supply civilian personnel we had a very International atmosphere about those trials!
The shooting trials proceeded smoothly & successfully with each test being analysed fully & were completed over a period of some weeks culminating in a positive demonstration of shooting down a target aircraft under blind firing conditions. It was then time to return to RAF Boscombe Down, England & wind down the "Shooting" Trials Team.

Further testing of the AI Mk 17 Radar System continued at Boscombe Down in the RAF Gloster Meteor aircraft & the RAN Sea Venom Mk 53 FAW Mk 53, Serial No. WZ893 aircraft.

<u>AI Mk 17 Radar Training for RAN 808 Squadron Personnel at RNAS Abbotsinch</u>
The next phase of introducing the AI Mk 17 Radar into the RAN was conducted at the Royal Naval Air Station, Abbotsinch, Scotland (HMS Sanderling). In June, 1955 Chief Radio Electrician (Air) John Saywell proceeded direct from RAF Boscombe Down to RNAS Abbotsinch with a quantity of AI Mk 17 Radar equipment. Other members of the RANSMP who had been at de Havilland aircraft factory, Christchurch, Hampshire had already arrived at RNAS Abbotsinch, awaiting delivery of Sea Venom FAW Mk 53 aircraft & to prepare those aircraft for shipment to Australia on board the new angled flight deck aircraft carrier, HMAS Melbourne.

John Saywell set up the AI Mk 17 Radar System in the RNAS Abbotsinch Radar Workshop in readiness to incorporate late modifications into the equipment & to provide technical training to RAN 808 Squadron Radio personnel who were scheduled to arrive shortly thereafter.

In due course the RAN 808 Squadron personnel were trained in the technicalities of the new AI Mk 17 Radar as well as being trained in the operational functions of the equipment.

The late modifications were successfully completed in all Radar Systems & proved out prior to final installation in each aircraft being prepared for shipment to Australia. Some aircraft had their engines inhibited & those aircraft were cocooned in readiness for long term storage in Australia.

There were a couple of incidents during this stage of work & those were:-

- When a munitions storage facility adjacent to the airfield exploded, killing some civilian staff & causing debris to fall from the Air Radar Workshop ceiling on to the AI Mk 17 Radar equipment & all personnel in the workshop. There was quite some relief when those present realised that they were uninjured!
- At the time, the Irish Republican Army were very active in their campaign against the British & were then currently raiding Military Establishments & in particular targeting, at night, armouries to acquire arms & munitions. The "Powers Who Be" decided that protective action had to be taken at all Military Establishments. At Abbotsinch, all Chief Petty Officers were detailed to provide that protective action in the form of one man, at a time, during the "Silent Hours", providing a roving patrol with a particular watch on the armoury – they were ordered to inform no one as to what they were doing & provided with a revolver with three rounds of ammunition – in a pouch, with direct orders that under no circumstances was the revolver to be loaded unless they were being shot at when the revolver could be loaded & shoot to kill. John Saywell was detailed off for those patrols & he advised the RN personnel that if they got him killed they would be in a lot of trouble! Australia House, London & the RAN were completely unaware of this activity. The thought did go through John Saywell's mind, at the time, that in the event of such a confrontation that there was surely only one likely outcome & the odds of success were not going to be stacked in his favour! Years later, John Saywell asked his immediate superior officer, at the time (Lt (L) J.G. Somervelle RAN) if he had been aware of those patrols – he had been completely unaware of the patrols!

AI Mk 17 Radar System Heat Trials in Libya

After RAN 808 Squadron personnel had been provided with technical training by John Saywell at RNAS Abbotsinch there was still one more trials task to complete for the AI Mk 17 Radar System & the Sea Venom FAW Mk 53 aircraft, Serial No. WZ893 & that was the "Heat Trials". Arrangements had been completed to conduct those trials in Libya. The RAN personnel allocated for those AI Mk 17 Radar System trials were Lt (L) J.G. Somervelle, Chief Radio Electrician (Air) T.L. Bail & Leading Radio Electrical Mechanic (Air) G. Kelly.

The location selected for the Heat Trials was at the International Airport at Idris, near Tripoli in Libya where the RAF had a Detachment. The timing was during the Northern Hemisphere Summer of 1955 & flying days were selected to be completed on days when the temperature was 100 Degrees Fahrenheit or more. The AI Mk 17 Radar System performed correctly during the tests. During those trials the Sea Venom aircraft was flown by a Royal Navy Pilot with the Observer/ Navigator/ Radar Operator being Lt Cdr Gavin Kable RAN.

Setting up the Radar Workshop in HMAS Melbourne

HMAS Melbourne berthed at King George V Dock, Glasgow & embarked the Sea Venom aircraft & RAN personnel from RNAS Abbotsinch, departing for Australia in March, 1956.

During the trip to Australia, Chief Radio Electrician (Air) John Saywell set up the Air Radar Workshop facilities & provided further technical training for Squadron personnel

A couple of incidents occurred on the run to Australia :-

- The first was when HMAS Melbourne was southbound in the Suez Canal & slowed for an approaching Northbound convoy of ships & there was a very strong cross wind blowing. The Melbourne presented a massive "sail area" added to by a mass of aircraft on the flight deck with wings folded upright; the "sail "took over & slewed the Melbourne almost broadside in the canal! There were some hectic moments in regaining control with the stern almost on one

bank of the canal! The Captain later addressed the Ship's Company & stated that one lesson learnt from that exercise was that an aircraft carrier with aircraft parked on the Flight Deck should never consider slowing down for an approaching convoy in the canal!
- The second incident occurred in the Red Sea when there was the alert of "fire below" – a dreaded call! The fire was quickly extinguished & we proceeded to Australia without further incident. .

Setting up the Radar Workshop at RANAS Nowra – HMAS Albatross
In early September, 1956 John Saywell was Drafted from HMAS Melbourne to RANAS, Nowra (HMAS Albatross) & was allocated I/C of the new Air Radar Workshop which was at that time a bare shell building. John Saywell set up this workshop to cope with the maintenance of the Venom Aircraft AI Mk 17 & the Fairey Gannet ASV Mk 19B Radars & provided instruction to technical personnel & to aircrew Observers so that they better understood the operation & capabilities of their equipment.

This completed the introduction of the AI Mk 17 Radar equipment into RAN service.

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ASV Mk 19B

By Chris Poole

ASV Mk 19B grew out of an immediate post war (1945- 46) TRE/Ekco (note 1) research program to investigate the feasibility of Cloud and Collision Warning Radar (CCWR), the result of which was the Ekco E34 search radar set.

By the end of WW2 it had become woefully apparent that there was a need to have a new 'fleet' Anti submarine aircraft since the Fairey Firefly, which had been converted to this role, was showing that there was very little design development left in the airframe and it was also suffering from 'wartime' era radar. This led to the Admiralty issuing specification GR.17/45 for a new aircraft which would have an ASV role, have 2 engines, be capable of carrying a range of weapons and have a Radar suite which could be capable of detecting submarine snorkels and periscopes in various sea states. The result of this was the Fairey type Q which became the Fairey Gannet.

Since TRE were already working with Ekco on CCWR and knew of the potential of the E34, this Radar was developed into the Ekco Type E38, which was to all intents and purposes ASV-19. The original design concept was for a 'POD' Radar to be fitted under the starboard wing (similar to the American Gruman Avenger TBM-3) and this dictated that the Radar had a conventional scanner unit with a 150 degree azimuth sweep. This Radar was the ASV Mk 19A.

Since the Gannet was late in service, in 1953 the Royal Navy/FAA acquired an undetermined number of Gruman anti-submarine warfare versions of the Avengers in 1953 under the Mutual Defence Assistance Program (MDAP). These aircraft were designated the ***Avenger AS Mk IV*** or ***AS Mk V***, and were used in the ASW role until the introduction of the Gannet in 1955. In these aircraft the American Radar was removed and replaced with ASV Mk 19A. In conjunction with this, a T1 variant of Percival Sea Prince was produced to act as a flying classroom where the ASV 19 was conventionally mounted in the nose, and with 3 scopes fitted on workstations in the cockpit so that 3 Radar Operators/Observers could be trained at any one time.

The Gannet evolved with a retractable dustbin Radar suite, hence the need to redesign the scanner and indicator unit, which became ASV Mk 19B.It is fairly certain that these units were made under a separate contract with EMI, using similar design principles to H2S units.

Note 1. TRE is Telecommunications Research Institute, and was later named RRE, Radar Research Establishment. Ekco was the trade name for E.K.Cole Ltd. The Radar/Telecom section set up in 1952 as a separate division called EKCO Electronics Limited.

Editor's note: More information about the development of the ASV Mk 19B may be obtained from www.ekco-radar.co.uk/ASV19/asv.php. As well, the author of this article has published a further

article about the development of Radar and WW2. This can be viewed on http://www.malmesbury-memories.co.uk/wartimeindex1.html.

Following is a copy of the full service report of ASV Mk 19B, classified as SECRET until 2002, submtted by Mr Chris Poole.

SERVICE TRIALS UNIT

R.N. AIR STATION

FORD

SUSSEX

SECRET

Report Number 509/52	Preliminary Performance Assessment of A.S.V. Mark 19B
Date: -	12th February 1952

DISTRIBUTION

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Telecommunications Flying Unit, Defford	1 copy

1. INTRODUCTION.

(a) Authorisation.

Trial number 533/Misc/182 was authorised by Flag Officer, Air (Home)'s form 101 number 1545/579F/460 dated 24th May 1951, which was accompanied by a questionnaire and by Admiralty letter A/AWD/401/50 of 7th May 1951.

(b) Officers concerned.

Lieutenant Commander G.T. Turner R.N.	Observer.
Mr G.L. Holmes – Commissioned Observer R.N.	
Lieutenant G. Dunworth R.N.	Pilot.
Lieutenant (L) K. Lobb R.N.	Electrical Officer.

(c) Sorties and Flying Times.

Lieut. Cdr. Turner	6 sorties	11 hrs. 50 mins.
Mr G.L. Holmes	26 sorties	44 hrs. 40 mins.
Total	32 sorties	56 hrs. 30 mins.

(d) Previous reports.

An interim report, number 507/51, was issued on this equipment on the 31st December 1951.

A previous report, number 511/50, on the commercial predecessor of this equipment, was issued on the 31st July 1950.

2. OBJECT OF THE TRIAL

The object of the trials is the preliminary performance assessment of the equipment before the full Service trials, with particular reference to the suitability of the scanner, indicators and the control unit.

3. DESCRIPTION OF THE EQUIPMENT

A.S.V. 19B radar equipment has been adapted from the cloud and collision warning equipment manufactured by E.K.Cole Ltd. preliminary service trials of which were carried out by an observer from this unit between 17th and 25th July 1950.

The major differences between the original and this equipment are the provision of one larger indicator using a six- inch cathode ray tube and the use of scanner X 432. The set now provides: -

i. P.P.I. on 10 and on 40-mile ranges.

ii. An open centre control on the 10-mile range to give more accurate bearing indication at short ranges.

iii. Range markers, which appear as concentric circles every 2 miles on the 10-mile range and every 5 miles on the 40-mile range. A marker on/off switch and brilliance control has been provided for these trials but it is understood that the on/off switch will be deleted from future equipments.

iv. Scanner stabilisation in roll and pitch, and tilt control of the 6-degree beam between 5 degrees up and 10 degrees down.

4. CONDUCT OF THE TRIAL

One flight with this equipment was carried out on 5th. September 1951, after which the equipment required servicing,

Five sorties were carried cut in the Portland area between 2nd. and 5th. October, with very promising results, after which the equipment again became unserviceable and the aircraft returned to Defford,

The aircraft returned to R.N. Air Station, Ford, on 23rd. October, and one sortie was carried out. Ranges obtained were low compared with those obtained in similar conditions between 2nd. and 5th. October, and the presentation was generally jittery end unstable. The aircraft therefore returned to Defford for further servicing of the equipment by the Telecommunications Research Establishment Malvern.

An observer from this Unit was detached to the Telecommunications Flying Unit, Defford, on the 20th November in an effort to speed up the trial. The excessive jitter had been cleared in the main by this date by T.R.E. but several other faults were still apparent, and much work: and many test flights were carried out before the equipment was judged to be fully serviceable on 29th, November.

The -aircraft was detached to R.A.F. Station, St Mawgan, on the 28th November to progress comparative trials with A.S.V. 13 installed in Shackleton aircraft (A.S.W.D.U. TRIAL 311 - 'Caster and Pollux'). The target used during this trial period was the trellis-topped international marker buoy off Godrevy Island. and ranges obtained compared favourably with ranges obtained by ASV-13 on the same target at the same time, but it was subsequently shown that all these ranges were below average. The Anson therefore returned to Defford and the trial was stopped until units that had been overhauled by the contractors became available. These units (the transmitter receiver, synchroniser and control unit) were installed and the aircraft returned to St. Mawgan by 6th December 1951. The general performance of the equipment, particularly the A.F.C. and the Tilt systems, was below the required standard and results, although much the same as those of the previous week, were disappointing compared to those obtained by ASV-13 in Shackleton's.

The aircraft returned to T.F.U. Defford on the 14th December and the radar equipment, together with the non-airworthy set used for bench testing by T.F.U. Defford was returned to T.R.E. The transmitter-receiver from the aircraft was returned to the contractors on 31st December for further investigation.

R.N. Air Station Ford was closed for the Christmas leave period from 18th December until 3rd January 1952.

An observer from the Service Trials Unit was lent to T.F.U. Defford on the 7th January to progress the trial and at the request of T.R.E. Malvern, an officer from the equipment and Trials section H.M.S. Ariel. Further very willing co-operation was forthcoming from Messer's. Gard and Oxborough from E.K. Cole Limited and a considerable amount of work was completed by this team during the period 7th to 14th January.

As no Shackletons were available from A.S.W.D.U. for the comparative trial between ASV 19B and 13, it was decided to continue operating from Defford to facilitate servicing of both the equipment and of the aircraft, and a total of 10 hours 40 minutes flying was completed against various targets in the Bristol Channel.

During this period the weather was consistently bad, and on the 9th January the radome was damaged when the aircraft flew through a violent hailstorm for about 30 seconds. Photographs of the damage and a technical appreciation are included under the maintenance section of this report (Missing). The equipment itself continued to give complete satisfaction.

It was expected that further progress could be made on the comparative trial with ASV 13 at St. Mawgan, so the Anson left Defford for St. Mawgan on the 21st January 1952. Unfortunately unserviceability prevented Shackleton co-operation throughout the week; one combined operation was attempted but the Shackleton was forced to return to base by engine failure after two runs on the target. Anson VM 306 continued to operate in the area, and during the period 21st to 25th January the

equipment operated satisfactorily against a wide variety of targets, including the marker buoy off Godrevy Island.

Results were good and compared favourably with the majority of those obtained by ASV 13 on previous occasions, but due to the unserviceability of the Shackletons the S.T.U. observer had no opportunity to operate ASV 13 and so give a more realistic comparison.

A second transmitter-receiver unit, brought as a spare was tried during the week to check that the modifications carried out by the contractor had cured the previous A.F.C. faults. This was proved, and the results obtained were comparable with the other, but it could not be used due to the recurrence of range marker jitter. This is an old fault known by the contractors, and subsequent T.R. Boxes have been suitably modified to prevent its recurrence.

5. OPERATIONAL PERFORMANCE

(a) Maximum Range

Detailed figures of the detection ranges against various types of targets are given in the appendices.

Since the scanner was positioned in the nose of Anson VM 306, only forward looking was possible; the fuselage effectively blanked all echo's from approximately 10 degrees aft each way.

Two ranges are quoted in the appendices and are classified as: -

I. Detection range

The range at which a target could be detected if its approximate relative position were known. At such a range, painting occurs once every three or four scans, and would possibly be missed by an operator doing an all round scan

II. Tracking range

The range at which a reasonably consistent painting occurs, and at which there is little possibility of an operator missing the 'blip'

(b) Target discrimination

Target discrimination is considered to be adequate for all normal A.S.V. search requirements. Two examples are given: -

I. The Scilly Islands, which first appeared as a single echo at 35 to 37 miles, split into five clearly recognisable groups at 25 miles – approach course 260 degrees true.
II. A large tanker steaming a half to one mile offshore on a course parallel to the coast was clearly identified as a single echo when stern on at a range of 25 miles.

(c) Accuracy of ranges and bearings.

The cursors supplied for this trial were marked with 30 degree/bearing lines only, and were made adjustable vertically and horizontally, so that a reasonable compromise in centring the trace could be made between the two indictors, which have common X and Y plate shift controls.

No inspection of the scanner was possible without removing the radome, so the cursor had to be lined up to the ahead position by inspection of the trace itself, which is not an accurate method. In addition, the bolts securing the cursor served also as securing studs for the visor, and it was possible to involuntarily alter the position of the cursor each time the visor was shipped or unshipped. The cursors when mounted were too far from the face of the tube, which gave rise to considerable parallax errors.

5 (c) continued

It was found that it was impossible to estimate correctly the bearing of any target on the 40-mile range due to the above inaccuracies, but on the 10-mile range these faults were not so apparent. It was found that all targets could be tracked very accurately down the 'on top' position.

Accuracy of range estimation depends almost entirely on the accuracy with which the range marker circuit is set up. No errors were found at any time when comparing radar ranges with those from maps and charts, and the changeover of ranges from the 40-mile to the 10-mile range produced no inaccuracies.

(d) The effect of sea clutter

If the target can be picked up outside the range of sea returns, it can be tracked to the zero range for that height. An experienced operator can also do this if the target is detected up to two miles inside the extent of sea returns. It must be emphasised, however that in both cases considerable experience is required to achieve this on a small target since it requires critical manipulation of 'tilt', 'gain' and 'brilliance' controls, and possibly the use of the sea clutter filter.

The sea clutter filter as originally fitted was found to be much too fierce and was virtually useless when it was most required, homing on small targets in conditions of heavy sea returns. A service modification was carried out on the filter fitted to the rear indicator with a fair degree of success, but due to the high sensitivity of the receiver and the consequent rise in amplitude and extent of sea returns, investigation into the provision of an efficient sea clutter filter is still outstanding.

(e) Minimum range

Minimum range due to height, which were reasonably consistent in sea states of up to 4 were found to be as follows: -

2,000 feet	1 ¾ miles
1,000 feet	1 mile
500 feet	¼ mile
200 feet	zero

In sea states of 5 to 6 these minimum ranges were increased by approximately ¼ mile, but in these conditions zero range could always be reached if the height was reduced to 200 feet. No sea states greater than 6 were experienced throughout the trial.

6. MAINTENANCE

(a) General

At the start of the trial it was not expected that much new or conclusive information bearing on service maintenance would be obtained, for the following reasons: -

i. The transmitter-receiver, synchroniser (with its front panel serving as a junction box), servo-amplifier and controller were of the early cloud and collision warning radar series, of which fair experience had already been gained in previous Anson and Firefly installations and on the bench. Previous comments on these units are well known, and are catered for in the production ASV 19B series.

ii. The indicators fitted were also of the original type, one fitted with a CV 1530 cathode ray tube (a six inch tube using the same electrical circuits) and the other with a lens to give a magnified presentation, both indicators being modified to include individual control of range marker intensity and a sea clutter filter as used in ASV 15. The larger

tube has been adopted for ASV 19B, but no fully engineered model was available for the trial.

iii. The scanner X 432 was the first experimental model with many known defects, which will not be present in subsequent models.

iv. The aircraft was to be based at Defford, where any aircraft maintenance required would be carried out, while the responsibility for radar maintenance was to be that of T.R.E.

v. No airworthy replacement units were available in case of failure, and test equipment for the first line use was limited to a Monitor X 469, an echo box TS 62 and a Monitor 52, which was permanently installed in the aircraft.

It was accordingly decided to allocate one Radio Electrician (Air) to this project, liaison at office level being carried out at Defford and T.R.E. during any necessary maintenance or modification work.

(b) Narrative

First Phase – 1st October to 30th November 1951

1st Oct. The equipment was satisfactorily flight tested and flown to R.N.A.S. Ford.
2nd-4th Oct. Equipment operated satisfactorily.
5th Oct. The aircraft was returned to Defford as the gyro unit failed to erect. This was removed and subsequently returned to R.A.E. for investigation, a Control Unit type 512 being fitted for the remainder of the trial.
9th Oct. The aircraft returned to Ford.
10-16th Oct. The aircraft was unserviceable due to airframe damage. The following faults developed on the ASV installation.

i. Open circuit video lead to the second indicator

ii. Faulty time base valve (CV 138) in the synchroniser

iii. A slight time base jitter developed, but was not traced.

Note: During this time servicing was attempted by two Radio Electricians (Air) and by an Experimental Officer from T.R.E., but conditions were very unsuitable as there were no spare parts, no bench facilities and the units in the aircraft were not easily accessible.

17-18th Oct. The slight jitter was accepted, the equipment otherwise serviceable.
19-20th Oct. The aircraft was returned to Defford for engine maintenance
23rd Oct. The aircraft and radar were serviceable and were flown to ford, where ranges obtained were poor
24-26th Oct. The aircraft returned to Defford where a performance check was carried out, the Transmitter-receiver re-aligned, a new crystal (CV 253) fitted, and the I.F. Strip checked at T.R.E. An improvement in performance resulted, and a tendency to overload tripping was traced to too high an output voltage from the motor generator type 4B. This was rectified.
29th Oct. 7th Nov A serious attempt was made to locate the origin of the time base jitter, the following contributory causes being found: -

i. Poorly fitting valve holders in the synchroniser giving intermittent contact with vibration.
ii. Vibration arising from an unbalanced blower motor fan in the synchroniser.
iii. Microphonic valve, paraphrase amplifier (VC 138) in the synchroniser.

During this period connector faults developed giving loss of signal crystal current and three phase voltages. These faults were rectified.

Maintenance Cont.

8-23rd Nov. During this period it was confirmed that the R.F. performance was satisfactory, but the loss in overall performance was due to poor operation of the A.F.C. circuit, which was subject to intermittent fast fluctuation, the cause of which could not be traced. During this period and later, less T.R.E. effort could be made available as the trial and its attendant investigations were lasting longer than had been anticipated. A service modification, increasing a condensor value, was made to the second indicator to make the sea clutter filter less fierce in operation. A limiting crystal diode (CV 448) failed in the first indicator, but this circuit will not be included in the final version of the indicator.

27-29th Nov. The aircraft operated from St. Mawgan, but the level of performance reached in early October was not attained.

Second phase – 30th November to 31st. December 1951

30th Nov. At a progress meeting at the contractors, E.K. Cole Ltd., it was decided to suspend the trial until and overhauled system, less the scanner, could be provided by the contractor, to be on loan for the remainder of the trial.

4-5th Dec. The replacement transmitter-receiver, synchroniser and controller were installed and accepted by T.R.E.

6-7th Dec. The aircraft operated from St. Mawgan, but the general performance and the A.F.C. circuit were still not up to the required standard.

10-17th Dec. Ditto

31st Dec. The Transmitter-receiver was returned to the contractor for investigation.

Third phase – 3rd January to 28th January 1952

3rd Jan. At the ASV 19 progress meeting it was agreed that the trial should be brought to a conclusion as soon as possible and that the contractor should be invited to fly with the system to assess its performance, in an endeavour to clear up the A.F.C. troubles. At T.R.E. request the technical co-ordination for the remainder of the trial was undertaken by the Air Officer of the Equipment and Trials Section, H.M.S. ‘Ariel’ working direct with the contractor as necessary.

7-8th Jan. Measurements of S.W.R. and frequency pulling were made on the installation to prove that the A.F.C. variations were not due to imperfections in the Waveguide run or scanner. The results were uniform and of a high order.

9-11th Jan. The following modifications were carried out by the contractor: -

i. The A.F.C. circuit in the transmitter-receiver was modified to include damping resisters of 1K across L201 and L202, reducing the gain and giving better lock-on discrimination between the I.F. and the second harmonic of half the I.F.

ii. The synchroniser was modified to improve range marker intensity by increasing C26 to 68pf and to reshape the bright-up reducing intense brilliance at the centre of the indicator, by increasing R61 to 100K.

Subsequent ground and air testing disclosed the following: -

i. Connector faults had developed leading to the loss of three phase supplies and the loss of the horizontal deflections to the second indicator.

ii. Stabilisation was inoperative, and the control unit type 512, which had become very stiff to cage and un-cage was replaced. The faulty unit was later lubricated and worked satisfactorily. Tests were carried out on the servo system using dummy gyros, and its operation adjusted to give oversawing for 5 degrees displacement, instead of 10 degrees as previously aligned. This was done to improve stabilisation, which was sluggish in rough air.

9-11th Jan.Cont.

iii. The A.F.C. was intermittent in operation and Klystron voltages were abnormal, a subsequent investigation by the contractors disclosing an intermittent heater-cathode short circuit in the discriminator, CV 140.

iv. The R.F. performance was poor, and was found to be due to a low power magnetron, CV 370.

14-15th Jan. The installation functioned well, the performance being as good as that experienced at the beginning of the trials.

16th Jan. Repairs were carried out on the radome, which had been damaged by hail on the 9th January. Small patches of neoprene had flaked off, and the exposed laminate there-upon ‘blistered’.

17-18th Jan Radar performance was good.

21-25th Jan The aircraft operated from St. Mawgan, the general performance being good, although at the end of this period there were equipment warning peculiarities (the absence of open centre, a short double-sided trace on the 40 mile range and an intermittent firing of the transmitter). These faults were repeated at the contractors on the 28th January, and were found to be due to low input voltages. The power supplies to be used for Gannet AS Mk1 will include an inverter type 202 with a thyraton control unit, giving 115v single phase supply controlled in voltage and frequency to close tolerances. A spare transmitter-receiver and synchroniser were borrowed from T.R.E. for this period and modified to the same standard as the aircraft system. The transmitter-receiver was tried in the aircraft in order to obtain a comparison but it produced woolly marker rings on the 10-mile range and was not flown. This fault was referred to the contractors, who had experienced it before in certain units. It is due to prepulse generator instability, and will not occur in production units.

(c) Remarks on individual Units

As has already been indicated, the experimental nature of the installation and the fact that it was not until the final phase of the trail that maintenance was under the direct control of the services do not allow fair answers to be made to the questionnaire, nor conclusions to be drawn from them. The following points did, however arise.

i. Stabilisation System.

(a) A marked improvement resulted after increasing the signal Vs feedback ratio in the servo-amplifier to give one overswing for 5 degrees displacement. However the scanner did not appear to move smoothly, but in a series of steps. The system is not difficult to set up in the aircraft.

(b) Insufficient experience was gained of the gyro unit type 5, as a control unit type 512 was in use for most of the trial.

ii. Tilt System.

A makeshift tilt system was in use, which was unstable and its relays gave ‘splash’ on the display.

iii. Scanner.

Full comment cannot be made on this early model, but sub-units are incorporated for ease of servicing. A directive feed was incorporated in the Waveguide run.

Maintenance Cont.

iv. Indicators.

No comment can be made on the layout or accessibility. The tube in use CV 1530D, although an improved version of the early CV 1530, is still subject to electrostatic defects such as accelerator shadow, which if not appreciated lead to a distorted display. It is desirable to set brilliance to maximum during the warm up time to overcome this.

(d) Test Equipment.

In general the test equipment should be similar to that of ASV 19A with the addition of a small number of items peculiar to the scanner and stabilisation system.

7. CONCLUSIONS AND RECOMMENDATIONS.

(a) General

After a promising start to the trial in October 1951, considerable delay was experienced due to unserviceability. It is felt that this delay could have been greatly reduced if more continuity had been available in the day to day servicing of the equipment, and if the contractors had been approached earlier. Such action was pressed by the service representatives at T.R.E.. Continuity was only achieved when an officer from the equipment and trials section, H.M.S. 'Ariel' assumed responsibility for the technical co-ordination of the trial. When the contractors were invited to fly with the equipment the two major faults were investigated and rectification action taken within a week. The equipment subsequently flew for approximately 20 hours in 14 days without further adjustment.

From an equipment point of view the main advantage obtained from this trial was the investigation into the A.F.C. unit and its subsequent modification to give a more reliable performance facilitating alignment.

(b) The stabilisation System.

This has been improved by the adjustments detailed in the maintenance section of this report, but movement in both pitch and roll is still jerky. The effect of this operation operationally is that in turbulent flying conditions large sectors of the scan are missed as the aircraft rolls and pitches. It is realised that the type of aircraft to be fitted with ASV 19B will not be affected so violently by such conditions as an Anson, and for this reason this system is considered to be adequate if the fault cannot be cured without delay.

(c) The Tilt System.

The tilt system has given considerable trouble, but critismns of it are well know by T.R.E., who gave assurances that the faults experienced during this trial will not be repeated in later models of the scanner. These faults have been: -

(a) If the tilt was set at 5 degrees or above, the scanner could not be returned to horizontal except by breaking the scanner On/Off switch and inching the scanner while slowly moving the control towards zero. The higher positive tilt settings were therefore blanked off and will be deleted from future models.

(b) Excessive jitter occurred when the control was moved in a negative direction. This jitter, sometimes accompanied by time-base splash, steadily worsened as

the trial progressed. To reach a given tilt setting of , say minus 4 degrees, it was necessary to move the tilt control to minus 7 degrees and then return to the required setting in a positive direction.

(c) Control of tilt is sluggish, and it is felt that the general operational usefulness of the equipment would be enhanced if the tilt follow-up could be speeded up. It is, however, acceptable if this is likely to involve major modification action and the consequent delay in production.

(d) The Indicator Units.

Two indicators were fitted in this installation, a six-inch high intensity low persistence green tube, and a smaller medium intensity medium persistence orange tube fitted with a magnifier. Both tubes used the same electrical circuits, and had only one minor fault throughout the trial. The large tube has been adopted for ASV 19B but no fully engineered model was available for the trial. The following remarks are therefore made for completeness only.

i. The magnifier on the small tube was most effective, and in fact one of the two operators preferred the medium persistence amber colour as being more restful, while giving detection ranges comparable with the high intensity green tube. It is therefore recommended that both types of tube be used for the full service trials of the equipment.
ii. During the latter stages of the trial an amber filter was made locally and fitted to the main green, indicator. It proved most effective in reducing glare. It is felt by the operator concerned that the cursor itself could well be made of this colour, but as experience was limited to one operator it is recommended that both clear and amber cursors be supplied as alternative fittings for the full service trial.
iii. It is considered that the cursors supplied for this trial were positioned too far from the tube, which gave rise to excessive parallax error.
iv. It is recommended that the method of securing the cursors and visors be improved, since the act of fixing the visor to the indicator in the present method tends to move the cursor off alignment. The problem might be solved by locating the visor with securing studs athwartships. As present these studs secure both cursor and visor.
v. It has been recommended to T.R.E. that additional half inch lines be engraved around the circumference of the cursor to aid bearing estimation of distant targets for plotting purposes, and the cursors supplied for the full service trials will be so engraved.

(e) Visors.

The visors supplied for this trial are considered to be adequate, with the following provisions:-

i. The inside of the visor should be finished in dull black. The operators have been seriously affected by the extreme glare reflected from the inner walls of the indicator. This reflection was partly reduced when the amber filter, mentioned in Para. (d) (ii) above, was used, but was still in existence.

ii. Every effort should be made to achieve as close a fit as possible between and the visor and the front face of the indicator. This fault is not readily apparent in the Anson aircraft, which is conveniently fitted with sunblinds, but can be very troublesome in an aircraft not so fitted.

(f) The Control Unit.

This differs considerably in layout from the production version, and therefore only general recommendations can be made.

i. The scanner On/Off switch should be retained in the production version to enable the scanner to be stopped in order to facilitate tuning and comparison of video strengths when estimating optimum tilt settings for various heights.

ii. The size and shape of the controls most often used is considered to be of equal importance to their relative position on the Control Unit. It is therefore recommended that the operational controls, which are the gain, brilliance, tilt and sea clutter filter controls, should be of such shape and size and be so positioned that they can be readily identified by touch. This is an essential requirement.

iii. It is further recommended that the focus control be placed away from those mentioned above. Time is sometimes lost at a critical stage of a homing if this control is moved inadvertently.

(g) <u>Installation.</u>

The following recommendations are made with particular application to the installation of ASV 19B in an Anson aircraft for full service trials, but recommendation (i) applies generally.

i. The installation should be laid out in accordance with service representatives, to make easy access to the following components: -

    (a) The Gyro Unit, in case a control unit type 512 has to be used, which requires caging and un-caging in flight.

    (b) The front of the transmitter-receiver and the directive feed.

    (c) The junction box, the front of the servo-amplifier, and the synchroniser.

Generally speaking it is desirable to have to remove one or more units in order to reach another.

ii. Two complete sets of units produced to ASV 19B standards should be used, with a fully engineered scanner.

iii. A new radome will be required (after the damage to the original one) and an access panel to the scanner components should be incorporated inside the aircraft to facilitate alignment of the servo system and the indicators.

iv. The radar primary supplies should conform to those used in Navel aircraft.

v. The intercommunication system should be modified to the users requirements.

vi. Test equipment to enable a daily assessment of performance to be made should be provided.

Signed

Lieutenant Commander R.N.
A/Commanding Officer
Service Trials Unit.

The Bailey Boys

By Cherub Log

The following comprise extracts from data created by Historical Records of Australian Science, "The Bailey Boys" by Walter Fielder-Gill; "Radar at Sydney" by Robert Slatyer; an address given by Bob Slatyer at the Bailey Boys 50th anniversary Reunion September 1994; and biographical notes compiled by John Medhurst. The author acknowledges all these references.

In 1941, the Department of Physics, University of Sydney was selected to train men in the science of Radio Location, later to become known as Radar. The major thrust for this was through the Royal Australian Air Force, which at the height of its influence established 142 ground Radar installations in the SW Asia Pacific region. The Royal Australian Navy also participated in this program to a lesser degree than the RAAF, mainly because the RAN had a limited number of ships in which Radar could be installed and effectively operated. The man charged with the responsibility of developing and delivering the lengthy and high pressure training course was Professor Victor A Bailey, University of Sydney. A natural consequence was that Victor Bailey's charges came to be known as Bailey's boys, and subsequently, The Bailey Boys.

The first intake, mainly, but not all, second year undergraduates of Sydney University, commenced their training on the 15th September 1941, concluding in February 1942. Thirty eight of these then went on to eight weeks administrative training at the University of Melbourne, and upon completion were commissioned as Pilot Officers RAAF. Then followed twelve weeks training on secret Radar specifics at RAAF Richmond.

Upon entering the initial training, the intention was that graduates would join the RAF to participate in the European war, but when Japan entered the war in December 1941, all were retained to assist in Australia's defence.

The second course commenced in March 1942 with undergraduates from five Australian universities. In this class were fifteen RAN trainees, the only RAN officers to be trained in the Bailey Boy program. Fourteen of the initial fifteen successfully completed the University of Sydney training. They were then sent to Flinders Naval Depot for 6 weeks officer training, followed by a period at what was to become HMAS Watson at Sydney's South Head. At South Head they familiarized themselves with contemporary Radar equipment, and were then each sent to different ships and shore establishments for operational duties.

There were three more courses throughout 1942 and to January 1943, all to provide the RAAF with Radar specialist officers. The Army then enrolled men in two courses, the last one concluding in March 1944. In total, there were 249 Bailey Boys. Of these, 160 were commissioned in the RAAF, 14 in the RAN and 75 in the Army.

It is well beyond the scope of this chapter to give even an abridged summary of the University of Sydney training content. However, the following will offer a glimpse into the education process provided to the Bailey Boys.

The accent was on understanding the basics of the technology by a thorough examination of the underlying mathematics and physics, supplemented where appropriate by exercises. Some of the topics included analyses of complex circuits using differential equations and a vector approach to the steady state, and the use of operators and complex numbers. These techniques were applied to concepts such as coupled circuits, transmission lines, attenuation and wave generation to name just a few. In all about 125 mathematical equations were examined and used. There were lectures on topics such as thermionic valves, cavity resonators, types of oscillators, amplifiers, phase inverters and harmonic resonators. As well students studied metalwork, woodwork, the use of equipment and safety considerations. Wave form generation and propagation received a lot of attention. To assist in comprehending the advanced mathematical treatments, basic maths such as trigonometric and hyperbolic functions, differential and integral calculus and Fourier Analysis were thoroughly explored. Throughout, there were 34 major exercises to be completed, regular tutorials, and periodic one hour examinations.

The desired outcome of this intensive training program was to create a cadre of technical officers who would be capable of assuming lead roles in the design, development, installation, and on occasions the repair of obscure operational faults, of Radar technology. As well, these men would be required to devise Radar counter measures, to assist in the creation of maintenance handbooks for the various Radar models being produced, to liaise with contractors and civilian manufacturers, to be the administrators of Radar installations and to be the mentors of the maintenance technicians. All this after an incredibly short period of about 12 months training. Considering that all were second year university undergraduates aged around 19 upon commencement of their training, the desired outcome became a remarkable success.

Overall, the consensus opinion shared by the Bailey Boys is that the program was very worthwhile. There are however supporters and detractors in specific areas. Some feel that the exhaustive study of the underlying theory provided them with the ability to "think outside the nine dots" when addressing any of the problems encountered when operational, and that this was most valuable. There are others who feel that lesser theoretical treatment of some topics such as alternating current theory would have allowed more time to study some of the practical considerations such as antenna design, because antenna efficiency is key to the success of any Radar. Perhaps Professor Alf Pollard's question summarizes this apparent dilemma, "Could we have won the war without knowing about Fourier Theory?" Alf Pollard's question is rhetoric, and we will never know the real answer.

RAN Bailey Boys served in the HMA Ships Australia, Shropshire, Hobart, Manoora, Bataan, Yandra, Kanimbla, Westralia, Faye C, Kybra, Townsville, Swan. As well as these shipboard responsibilities, Bailey Boys had different assignments as Port Radio Officers, Dockyard Officers, Instructors, Installation Officers, Radar Counter Measure Officers. They served in various Papua New Guinea east coast locations such as Madang, Lae, Aitape. As well they were on the New Guinea west coast, and further north and west of what is in 2004, Irian Jaya, into the Indonesian islands of Sulawesi and the Halmaheras. In terms of wide ranging operational locations, the cream on the cake, so to speak, was that two were in Tokyo Bay for the Japanese surrender.

Following are snapshots of the WW2 experiences of the 14 RAN Bailey Boys commissioned. Except for those entries marked with **, the information has been provided courtesy John Medhurst.

George Campbell : Did not complete the Bailey Boy course. Demob 20/5/46 as Lt(Sp)

Richard (Dick) Coyle: 1942 Rushcutter & Watson. 1943-44 Radar Officer Manoora. 1944-46 Port Radar Officer Cairns and Darwin.

Kenneth Andrew Glover **: Demob 20/5/46 as Lt(Sp)

Collins Greaves **: Demob 24/1/46 as Lt

John (Jock) Robert Hornsby: 1942-43 Rushcutter & Watson. Directed to specialised work on Radio Counter Measures (RCM) Brisbane & Darwin. 1944-45 Shropshire and other ships with RCM equipment. Demob 18/2/1946 as Lt(Sp)

Norman Louat **: Rushcutter, Broome, Moreton Westralia, Madang, Bingera, Aitape. Demob 7/3/46 as Lt.

Ronald (Ron) Joseph Lukies: 1942-43 Rushcutter & Watson. 1943 Radar Section Navy Office preparing standing orders and instructions for Radar personnel, analysis of Radar faults and improving component design. Subsequent short service in HMASs Townsville and Swan. Later to Radar-Radio Workshop at Leichhardt, then to HMAS Bataan. Demob 1946

Alistair John MacKenzie: 1942-43 Rushcutter & Watson. 1943-45 Radar Officer HMAS Australia. Demob 17/9/45 as Lt (Sp)

Archibald (Archie) John McArthur: 1942 Rushcutter & Watson. 1943 Williamstown Dockyard, Brisbane Dockyard fitting of shipborne Radar. 1944 New Guinea, maintenance of shipborne Radar from Madang to Milne Bay. 1945 Brisbane dockyard Radar maintenance. Demob 30/11/45 as Lt(Sp)

Colin William McIvor: 1942-43 Rushcutter & Watson. 1943 Radar Officer HMAS Hobart until Sydney return for damage repair. 1943-44 Yandra operator training and convoy work. 1944-45 Assistant PRO Melbourne. 1945 HMAS Semaphore PRO Adelaide fitting out AMS. Demob 6/2/46 as Lt(Sp)

John Philip Medhurst: 1942 Cerberus OD Signal School. 1942-43 Rushcutter & Watson. 1943-44 Radar Officer Kanimbla. 1944-45 Instructing at Watson. 1946-47 Radar Officer Warramunga and Bataan. Demob 6/3/47 as Lt(Sp).

Daniel (Dan) Frederick O'Keeffe: 1942-43 Rushcutter & Watson. Then to Brisbane fitting out basin doing Radar installations. Then to Base Radar Milne Bay and Madang. Then Radar Repair ship Faye C working around New Guinea. 1946 to Brisbane fitting out basin again. Demob 19/11/46 as Lt(Sp)

Robert (Bob) Thomas Slatyer: 1942-43 Rushcutter & Watson. April 43 – June 43 HMAS Hobart. June 43 – October 43 Watson writing A76 handbook. October 43 – January 46 Radar Officer Shropshire. January 46 – September 46 HMAS Leeuwin. Demob 26/9/46 as Lt (Sp)

Clive Reginald Taylor: 1942-43 Rushcutter & Watson. 1943-46 Section 22, Office of Chief Signal Officer GHQ. SWPA Brisbane, RCM work. Demob 16/3/46 as Lt(Sp)

Ronald (Ron) Henry Whitten: 1942-44 Rushcutter & Watson. Operator training HMAS Kybra. 1944-45 Radar Officer HMAS Hobart. 1945-46 Cerberus. Demob 9/3/46 as Lt(Sp)

** At the time that John Medhurst was compiling the foregoing information, Greaves and Glover were deceased, and Louat could not be located. Hence a lack of information about these three.

In conclusion, to quote Bob Slatyer, "Whatever the position to which they were appointed, the Navy Bailey Boys consider they were privileged to have been able to attend the course and that the instruction given was of great value to them during their Service career."

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WW 2 Wireless & Radio Mechanics

By Cherub Log

In September 1939, Australia followed Britain and declared war on Germany. At that time, the impending hostilities were half a world away, and posed little threat to Australia. In December 1941 when the Japanese launched their assaults on nations bordering the Pacific Ocean, matters changed dramatically. Instead of being an aggressor in a conflict 12,000 miles away, Australians were faced with the task of defending their domain from attack by a powerful, fiercely aggressive, determined and very close invader.

Traditionally and for organisational purposes, the Navy had branches of Engineering, Gunnery, Navigation, Communications, Supply, Electrical and Medical. Within the Communications branch there were the visual signallers, colloquially called the "bunting tossers", and the Telegraphists, aka "sparkers". The Telegraphist's main role was to operate the wireless telegraphy equipment communicating by Morse Code. Their subsidiary role was to maintain the equipment, which in the immediate pre war days, was fairly simple.

The challenge to 12,000,000 Australians of defending their vast land area encompassed by about 4,000 miles of coast line, equipped with meagre and largely outdated defence technology was daunting. To meet the challenge, many initiatives such as accelerated recruitment into the three armed services and mobilisation of industry to support a war effort were implemented. In the total context of this scenario, one of the many initiatives was the creation of a new branch of the Royal Australian Navy, the Wireless Mechanic branch.
In the early 1940s, the Telegraphists quickly found that the demands on their time and skills to handle the substantial increase in wireless traffic, as well as to man and to implement a training

program to meet the needs of the sudden big increase in recruits was becoming more difficult as each month passed. Coupled with this, there was a steadily increasing introduction of more technologically complex electronic equipment to the ships and shore establishments. It soon became clear that the maintenance role of the Telegraphist could not continue. To address this need, the new title of Wireless Mechanic was conceived late in 1941, and introduced to the RAN early in 1942 (CN0194/42 refers).

In order to turn this concept into reality, selected personnel were to be given a basic training course of 6 months duration at the Melbourne Technical College, later known as the Royal Melbourne Institute of Technology (RMIT). This basic training was followed by equipment training at the RAN shore establishments of HMAS Rushcutter and HMAS Watson in Sydney, and at HMAS Harman and the Belconnen Transmitting station, both in Canberra. A few of the selected personnel came from existing Naval ranks, but the majority was recruited from civilian life. These then became what we know today as the Hostilities Only Radio Mechanics (HO RMs).

Radio Direction Finding (RDF) was the name given initially to the very new and top secret device which could "see" targets over the horizon, and at night, by showing on special equipment the range in yards, and bearing relative to the ship's head or to the compass. As well, for detecting aircraft, it -could show the angle of elevation necessary for training the anti aircraft guns. Various models of this technology were developed, and it logically fell to the Wireless Mechanic to instal and to maintain it. The title RDF was soon changed to that of RADAR, an acronym of Radio Direction and Ranging. As the title Wireless Mechanic was then no longer completely descriptive, the maintainers' title was changed to Radio Mechanic. The Radio Mechanic (RM) then became responsible for the satisfactory performance of all electronic equipment in his ship. This was quite a responsible task. This change occurred in 1943 (CNO 414/43 refers).

Within the space of 12 months intensive training, the RM had the responsibility of keeping all of a warship's Radar and communication equipment fully functional.

Typically, the recruits were in their early 20s, and had secondary school education to year 5 level. Good passes in mathematics and physics were preferred. There were exceptions such as an older recruit with a strong background in radio.

Following the mandatory medical examinations and probity checks, the new recruits spent their first six weeks in the Navy "square bashing" at HMAS Cerberus. Cerberus is a large Naval training establishment at Crib Point Victoria. Those six weeks instilled a sense of discipline in each recruit, and taught him some of the basics of Navy life. The recruit learnt how to wear and to look after his uniform correctly, how to carry out the various drill orders, and generally to understand the subtleties of Naval routine. The facetious homily of "If it moves, salute it; if it is stationary then polish it; but if it wont take polish, then paint it" was not too far from reality.

All RAN recruits had this initial indoctrination which was then followed by specialist training at the various schools within Cerberus. For example, the Telegraphists went to the Signal School, the Stokers went to the Engineering School and so on. However, the Radio Mechanics were drafted to HMAS Lonsdale, a shore establishment located at Port Melbourne. Lonsdale became their home for the next six months in that this is where they slept, washed and ironed their uniform clothes and ate most of their meals. Each Monday to Friday, having had breakfast, they would travel to the Melbourne Technical College, later Royal Melbourne Institute of Technology (RMIT) for instruction in electricity, and in radio transmission and reception. The travel distance was not far, perhaps 7 kilometres, and for the earlier classes was on the back of an open tray 3 ton truck. Passenger comfort and safety were given low priority. Some later classes had the luxury of traveling by tram.

Not all RMs were billeted at Lonsdale. There were occasions when the population exceeded the capacity for accommodation. On such occasions, some RMs were billeted out in private residences, such as their own home if they lived in Melbourne prior to enlistment.

What happened subsequent to the basic training depended upon two factors. One was the instructors' assessment of each student's potential, and the other was the manpower needs. Most graduates were very keen to be given the training which would lead them to a sea going ship.

However, there were a number of shore based manning requirements such as the Naval Transmitting Station at Belconnen Canberra, HMAS Melville in Darwin, HMAS Magnetic in Townsville. As well, the advanced training in Radar was carried out at HMAS Rushcutter, and later at HMAS Watson when that establishment was commissioned. So quite a few RMs missed the glamour and excitement of being front line to the enemy.

HO RMs were assigned to 194 ships and shore establishments between 1942 and the end of 1945. Of these, 122 were sea going vessels. It is estimated that 363 men qualified as RMs in the period January 1942 through August 1945.

In early 1945, the RAN recognised that with the imminent cessation of hostilities, most of the Hostilities Only (HO) sailors would be demobilised, potentially leaving the essential services unmanned. To address this eventuality, a recruiting program of 12 years continuous service was introduced later in 1945 for all branches of the service. This carried on for a number of years after.

A schedule of Radio Mechanics necessary to man the estimated post war Navy, dated 13 August 1945 and promoted by DTSR Captain Alan McNicol showed how critical the situation was deemed to be, with an estimate of just 5 serving members who would transfer to the permanent forces, leaving a shortage of 152. The schedule indicated that 101 of these 157 RMs would be destined to serve in the 54 naval vessels in commission at the time, 33 would serve in shore establishments and there would be a 'pool' of 14. He subsequently revised his estimate to 285. However, 8 months later on 25 April 1946, the CO of HMAS Watson, Commander Neil McKinnon, proposed a total of 171 RMs to man 36 ships and 11 shore establishments. This program called for a selective recruitment to achieve 15 classes at the rate of 8 classes per year. Class duration was to be 39 weeks (In fact it became 49 weeks).

Following recruit training at HMAS Cerberus, trainee RMs spent 6 months based at what was HMAS Torrens, Port Adelaide. Daily they would be transported to the then School of Mines, later to be absorbed into the University of South Australia, for basic training in electrical and electronic theory and practice. Graduates were then sent to HMAS Watson, Sydney for training in Radar or W/T equipment, according to the manning needs at the time. It was considered to be too onerous on the students to expect them to learn all of the W/T and Radar equipment at the time. So there was initial specialisation in W/T or Radar, with cross training a year or so later.

The first class commenced training at the School of Mines in January 1946, and the last class completed the initial training in April 1949. During this 40 months period, approximately 180 Radio Mechanics graduated from the School of Mines training program. Commander McKinnon's crystal gazing 3 years previously proved to be remarkably accurate.

Subsequently, the Radio Mechanic branch was folded in to the Electrical branch, and different conditions were introduced to meet the changing needs of the service.

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Snippets

By "Skip" Distance

This is a collection of incidents, stories, happenings, illustrating some of the fun and hazards of Radar technology in the mid 1940s to mid 1950s.

<u>In May 1951 P O Radio Electrician Doug Hawke</u> was assigned to maintain the 960 Air Warning Radar aboard HMAS *Australia.* His first problem to address was to get the Trigger unit operating reliably. After many hours of frustrating and patient but unsuccessful work, Doug solved the problem by withdrawing the unit from its cabinet, placing it on a stool, and causing all available forced air outlets to be directed at it.

The next problem was that the output Lighthouse tubes repeatedly kept "blowing", requiring replacement. Technical experts from the Leichhardt Radio Test Room were called in, and for a time there was much head scratching. Then PO RE John Scanlan noticed a blob of aerial insulation material

hanging from underneath the cable where it joined the aerial filter unit. Somehow the aerial run had turned to carbon. Cable was replaced, and that fixed the premature demise of the Lighthouse tubes.

While in attendance, the Leichhardt boffins were directed to the Trigger unit problem. Inspection revealed that the ventilation for the cabinets had been wired in reverse. The hot air was blowing back down over the heat source, and apparently had been so doing for a long time.

For a brief period while operating out of Hong Kong, Doug was required to surrender his proprietorship of *Australia's* 960 to a team of Intelligence people who connected a Panoramic Adaptor (Spectrum Analyser) to 960's antenna, for the purpose of intercepting Chinese and Russian transmissions.

Chief Radio Electrician Phil (Lofty) Watson, tells a story to illustrate the considerable value of Radar operations being in the hands of capable operators. To have excellent equipment is not sufficient if the best is required of the Radar system.

It was in the late 1940s that an exceptionally heavy storm on the NSW east coast caused a large harbour pontoon (about 10 by 15 metres) to break free of its moorings in Newcastle harbour, and to be driven into the nearby off shore shipping lanes. The Newcastle Harbour authorities immediately issued a "Danger to Shipping" signal, and requested the RAN to initiate a search and locate exercise. HMAS *Quadrant,* then under the command of Captain Sam Beattie VC, on loan from the RN, was despatched forthwith from Garden Island, and shortly after commenced Radar sweeps. As well as "all hands to lookout", the search Radars were the 293 and 277 10 centimetre sets suited to long range, supplemented by 974 (3 centimetre) navigation Radar.

After about an hour of nothing reported, one Radar operator reported an occasional very small blip occurring once every 3 or 4 antenna rotations. By persisting the operator was eventually able to confirm that "there is something there". *Quadrant* was conned to approach and finally when only a very short distance away, the almost submerged pontoon was seen wallowing in the still very heavy swell. At best, only a few inches of the pontoon were visible above the surface of the sea, and this only for a few seconds as the waves washed over it. Indeed a hazard to shipping.

Lofty's point is that whereas the Radar equipment was capable of picking up occasional echoes from the almost submerged pontoon, it was the skill and perseverance of the operator which caused the pontoon to be found. Finding the recalcitrant pontoon was one thing, taking it in tow and proceeding back to Newcastle harbour at less than 3 knots all night in an uncomfortable heavy swell, was another matter to be told elsewhere at another time.

Greg Sharp recalls that in 1948 there was a problem with the 286 long range Radar installed at Watson's Bay. The trace 'bloomed', the cause being a leakage through the double diode 6H6 connected to the grid of the CRO. A new component had just arrived from the UK, and it was called a solid state diode (later called a transistor). Greg fitted this and fixed the problem. It wasn't too many years later that the transistor became a household word.

Greg was a recipient of the R.N. Herbert Trust Fund Award for his work in adapting a Miller Transitron circuit to provide a stable linear sawtooth to improve the bearing accuracy of the 286 Radar.

Roy King was a HO RM, having joined the RAN as a "Rocky" on 29/10/1942. Following his recruit and technical training, an early appointment was to HMAS *Bunbury*, a Bathurst class minesweeper (Corvette). Roy reports:

Bunbury was fitted with both A272 and A276. Display for the A272 was the single line A scan image, whereas the A276 had the more advanced PPI display. A272's antenna was the big old square type.

Ray Brown, ex Ch RE, reports that 55 years on he still has a small tin containing gramophone needles, obtained from Naval Stores, as spares for the A272 rotary spark gap electrodes.

On the topic of rotary spark gap, the Frigate *Culgoa* and Corvette *Cootamundra* had A276 Radar which had a rotary spark gap attached to one end of the motor generator which in turn powered the

A276. The rotor of the spark gap rotated at 3,000 rpm and it had 10 electrodes to arc over the stationary electrode, thus producing a pulse repetition rate (PRR) of 500 pulses per second.

When running, the spark gap was adjusted by means of a knob to bring the spark to a fine blue colour for optimum operation. The stationary electrode wore away rapidly, and was constantly replaced to keep the spark sharp. The amplitude of the initial pulse shown on the A scan was a good indicator that the spark gap needed adjustment. As the elecrode began to deteriorate, the amplitude of the pulse would diminish. The spark discharged the line/modulator which in turn fired the transmitter.

Ray also relates the following story about the fast anti submarine frigate HMAS *Quickmatch* during the early 1950s. *Quickmatch* was engaged in an anti submarine exercise with her consort *Queenborough*, both at slow speed in a big ocean swell, and in contact with a submarine. In this state a large blue pennant is shown to give visual indication that the ship has a submarine contact.

Quickmatch was flying the pennant when it wrapped itself around the 974 Radar aerial, bringing the aerial's rotation to a shuddering halt. Ray was in the operations room at the time, and seeing the aerial rotation cease for no apparent reason, cut the power immediately. Using his initiative, he grabbed the nearest tools he could see, which were a broken kitchen knife and a hammer, rapidly scaled the superstructure and cleared the bunting from the aerial's moving parts. 974's training motor was belt driven, and because of this and Ray's quick action, the motor did not burn out, and *Quickmatch'*s 974 was operational again promptly.

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Operations Rooms HMA Ships WW2

By Lt (Sp) R Slatyer RANVR

My sea time was spent almost entirely in HMAS *Shropshire,* so I will describe my recollections of the situation as regards Operations Rooms in that ship.

In Shropshire we did not have a centralised Operations Room as I understand all ships now have. Instead we had a number of different locations each of which had a particular function. These were:

<u>Navigation.</u> Directly under the bridge was the Plotting Office. This had a table on which the appropriate chart would be spread under a glass panel. A spot of light from underneath was moved to follow the ships course and speed, and the person on watch would mark its position at intervals. There was an opening above through which the chart could be viewed from the bridge. We had an American SG Radar with PPI display (the only PPI we had) , mounted in the Plot.

<u>Gunnery Control – Main Armament Surface Targets</u>. The TS (Transmitting Station) was installed well down in the ship and forward of the boiler rooms. It was manned by Bandsmen with a Warrant Gunner in charge. The fire control table could be described as a 'mechanical computer", and was slightly smaller than a billiard table. Information fed into it would be:
* Ship's course and speed
* Target range available from either the optical rangefinder in the main armament director or from either of the 2 Radar displays in the TS. These were the 285 with antenna mounted on the main armament director or the 273 which was independent. At all times the Radar range was more accurate than the visual, although in good visibility there was little difference.
* Target bearing. In conditions of good visibility visual bearing was more precise than Radar but in poor visibility or at night Radar bearing was adequate for the purpose. Target course and speed was estimated from this information, adjustments applied for wind etc, all providing the necessary data for setting the guns.

<u>Gunnery Control – High Angle Guns</u>. Shropshire had four twin mounts of 4 inch HA guns and a type 285 Radar with antenna mounted on the HA director. These guns were used for long range anti aircraft defence. They were controlled by a gun control table similar to but smaller than that in the TS.

<u>Gunnery Control – Auto Barrage Units</u>. We had four of these units, one for each main armament turret. I think that once the Gunnery Officer on the bridge had given an order to use a particular turret to

attack a particular aircraft, control of the operation was the responsibility of the Gun Captain in the turret.

Aircraft Warning and Interception. Air plotting Office. This was the closest we had to a modern day Operations Room, manned by Radar Plot ratings and a Specialist Officer in charge. *Shropshire* was fitted with a 281 air warning Radar. It was a powerful piece of equipment based on the technology of long range Naval W/T. but required careful attention to all aspects of fine tuning and maintenance as well as dedication to detail combined with great patience on the part of the operators to extract the best performance from it. Fortunately we had the right people to do that.

The information on positions of aircraft both enemy and friendly was recorded on a chart using the call sign "Porthole". The name "Porthole" was held in high esteem throughout the fleet and all members of the ship's company were proud to be associated with it.

Regarding other ships, I think that cruisers and destroyers would have had similar decentralised arrangements for navigation and gunnery control, taking into account the guns fitted. Their air warning Radar would have been used simply for air warning reporting directly to the bridge. HMAS Australia may have had an Air Plotting Office, but it would have been much simpler than in Shropshire. The reason that *Shropshire* was different was that before the hand over from the RNB, a complete set of current Radar and associated equipment was fitted.

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Radar Operator Training.

By Ron Whitten Lt (Sp) R.A.N.

Physical Situation

Training was done at South Head, an outpost of H.M.A.S. *Rushcutter*, which was responsible for the administration, while the school was run by RDF experts. Built in 1942 on the South Head's bluff was a school with classrooms and, right on the ocean's edge, another building housing the training Radars – an Australian 286 Air Warning set and a 272 Surface Warning set. These were used for training both operators and mechanics. Like at Rushcutter there was no accommodation at the school, so all personnel lived out, coming by bus or tram to South Head each morning and climbing the hill to assembly and roll call in the school grounds. Lunch was provided in an old church on the site.

Training Classes

Operator training came under School Master John Gloury, who delegated the task of arranging lessons, content and division of training between classrooms and operational sets. The lessons involved the principles of RDF, the kind of sets available in the RAN, how to turn them on and how to operate them. The lessons included how to plot and report the data received, and how to estimate aircraft height given the range at which aircraft were detected. The time table had to take into account the subject matter being taught, the availability of classrooms and the availability of sets for operators to train on, as these were also being used for mechanic training. Because operators would be going mainly to Corvettes it was essential that they understood fully the intricacies of the 286 and 272 that they would be responsible for as well as the essentials of plotting. Other ship operators had to know how to integrate RDF operation with gunnery.

By March 1943 the RN had well developed RDF operating principles and training methods, and these were used as a basis of the Australian training system. The RN also provided training films, like one showing RDF being used on a Corvette to detect submarine periscopes and the events following until the sub was sunk. This was a favorite among trainees.

Often there would be no room in the operating hut, so classes were allowed to spread out on the rocks nearby, often enjoying the sun more than the lessons. This was ample opportunity for the P.O. Coxswain, who would sneak up on them in an effort to find some-one skulking. Mostly he was frustrated.

Training at Sea.

There was a constant demand on Navy Office to provide a training ship, but it took a long time to materialise. In the meantime, H.M.A.S. *Kybra*, a cattle boat that worked between Albany and Fremantle in peacetime, had been converted for Asdic training. It became a de facto RDF training ship when it arrived in Sydney with a crew of "uncontrollable" RDF operators who had recently returned from action in the Mediterranean theatre and were not greatly impressed by the local "pusser" regimes. It was decided they would be replaced by a group of first time trainees, but by the time Kybra was ready to leave the old crew was back. I had joined the ship as the Radar officer, and wasn't very happy at what had happened. We were hardly out of the harbour before I was called to the operating room to be told the aerial of the 286 wouldn't turn. The aerial was controlled by an Asdic trainer, which I knew nothing about. Luckily, while leaning on the trainer, my fingers found a switch underneath, which set the aerial going as soon as it was turned. The "rascals" must have decided that I knew what I was about and we became well acquainted. The Jimmy of Kybra disliked the RDF people, who didn't work ship, so he found as many difficulties as he could for them. Whilst in the Eden area the RDF operators had to take the whaler for a row each morning. A great lark – around the nearest bluff that hid the whaler from Kybra and onto the rocks for fresh oysters, some of the best ever tasted.

H.M.A.S. Hobart

Towards the end of 1944 nearly all the Radar operators in the RAN had been trained or re-trained, and it was time to move on. (By this time the American name Radar was being used.) So in October, I was appointed to *Hobart* as second Radar Officer. The ship was still refitting at Cockatoo Dock, where the dockies had gone on strike to demonstrate to Admiral Keyes, RN, that they were unwilling to work. Working with dockies was tricky. Carrying aboard an urgently needed battery nearly caused a walkout.

Because I had been in charge of operator training for so long I knew the best and the worst of them, and used this knowledge in choosing Hobart's operator crew. I had to allow that I would be expected to choose the best, so asked for more and got nearly all I wanted. There were certainly some very good operators among them.

When the Cockatoo Dock refit was finished just before Christmas, *Hobart* went to the Jervis Bay area to work up. On Christmas Eve the ship was preparing for a relaxed Christmas Day. But just after midnight the Surface Warning operators picked up what was definitely a submarine periscope at about twenty miles to the south east. So it was up anchor and back to Sydney, with much questioning as to whether it had been a submarine detected that far away. I got a final answer to that question many years later at a lunch for former Ikara missile team members. Hugh Jarret, who was second gunnery officer in *Hobart* at the time, had stayed in the Navy after the war and had been involved with the Ikara missile development. Hugh had been in Germany and met up with submarine people who confirmed that a submarine had been in the area at that time and sunk a small tramp steamer.

This long range detection happened because *Hobart* had been fitted with the latest British Radar sets, which performed magnificently, and *Hobart* had good Radar operators. Later at Balikpapan on the east coast of Borneo, Colin Churchett, the operator of the 281 Air Warning set, picked up an echo in the grass that no-one else could see, which eventuated into a Japanese bomber coming from inland Borneo. This was followed in on the 281, and then handed to the gunnery Radars that helped the guns shoot the aircraft down. This was at night so the aircraft was never seen, just an echo in the grass until it appeared on PPIs as a series of dots coming to earth. While the aircraft was approaching the Fighter Director Officer had it on the Kryatron display and was calling up fighters from nearby carriers, but they didn't scramble in time to be of any use.

Another example of how good were *Hobart's* Radars was at the Brunei landings. Stooging around outside Brunei harbour, the Surface Warning set picked up a ship at around forty thousand yards. The usual report went out "Skunk bearing so-so, range so-so." It was well known that the approaching ship carried General Douglas Macarthur, but the US Navy ships accompanying took up the cry "Does the skunk smell?" "How badly does that skunk smell?" And questions of that ilk which went on for about five minutes when the US Admiral in charge called it a day.

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Supplies

By Cherub Log

French general of history is reputed to have stated that an army marches on its stomach. A similar sentiment might be attributed to the survival of technology in that unless there is a constant supply of spare parts and equipment, the technology will not survive.

Behind the front line of Radar equipment and operational personnel, during WW2 there was a constant stream of communiqués dealing with many aspects of supply. Some of the originators and recipients of these communiqués, which incidentally were categorised as either Most Secret, or Secret, were C in C East India, ACNB, PMG, a certain Colonel Jones who was Controller of Radio Supplies, Ministry of Munitions, 1st Naval Member, 2nd Naval Member, 3rd Naval Member, DCNS, Department of Munitions, Naval Stores South Melbourne, DNS, C in C China, NZNB, and the Naval Officers Commanding the stations at Durban, Colombo, Fremantle, Bombay, Kilindini and Drogue. There were many more. This alone added a degree of complexity to the appropriate management of the requirement to provide a suitable infrastructure in which the maintenance personnel could work effectively.

For some of the items, the classification of Most Secret is perhaps understandable. Examples were test equipment such as Field Strength Receiver, Wavemeters, Portable dipoles and signal generators all operating at 176 Mcs and 200 to 214 Mcs. Enemy knowledge of these might have given a clue to the Allied Radar equipment. Dozens of other items on messages classified as Most Secret seem to be an over use of the Most Secret classification. Examples were Set of chisels small; 6" warding file; Set of BA dies (0-10BA); 60 watt electric soldering iron. How unauthorised knowledge of the requirement of these items could have given the enemy a tactical advantage is a mystery.

The establishment lists of spare parts for major centres such as Durban, Colombo, Fremantle read like all of Dick Smith's 21st century stores, multiplied by a factor of 10. For example, a few of the hundreds of items were valves diode 6H6 quantity 480; valve triode 6AC7 quantity 880; Capacitor 100 μμF 400 V working quantity 1,040; Resistor 1 M ohm 1 watt quantity 2,480.

The organisation of maintenance items was thorough as the following examples illustrate

a) The standard ship's set of maintenance tools, perhaps 30 items such as steel rules, engineer's hammer, hand drill, long nosed pliers and so on.

b) The list of about 50 installation consumable stores, such as empire tape, torch batteries, emery cloth, red coaxial putty, carbon tetrachloride.

c) A Most Secret letter written 2nd March 1942 by Lt Cdr G.C.F. Whittaker to the O.I.C P.M.G. Laboratories Melbourne confirms the formal order for various items such as Power Supply Alternators, Aerial Arrays, Meggers, Avometers, Beat Frequency Oscillators, Tube Testers.

d) Another Most Secret letter written 14 January 1942 by Lt Cdr Whittaker to the O.I.C., C.S.I.R Radio Physics Laboratory, on behalf of the C in C East Indies Station advises that he (Whittaker) is in Australia for the purpose of arranging supply of various major items such as 40 sets of Australian type S.W. 176 Mcs, and 200 – 214 Mcs R.D.F sets, complete with all essential ancillary gear, 40 aerial arrays, and long lists of test equipment, spare parts and tool kits.

Of course, none of the equipment provided to whomsoever ordered it was free of charge. All had to be properly accounted for. So as well as the extensive process of inventory control, there was additionally the accounting requirement. Here are some examples taken from an account dated 11 February 1942:

a) 14 cathode ray tubes, total cost	£45.7.8
b) 3914 valves various, total cost	£10,972.17.5
c) 1296 batteries. Total cost	£96.0.0
d) I only 18KVA 1 phase 50 cycle 220/240V 1500 rpm alternator	£180.0.0
e) 4 sets of TR switching units, total cost	£109.8.0

This account comprised approximately 480 line entries, and a total cost of ₤109,818.12.5

Some of the transport arrangements for orders for shipment from Australia to the Eastern Fleet were per the following ships in the months shown:

SS Tandra. May 1942
SS Oresles. June 1942
SS Mulbera. July 1942
SS Rajula. August 1942
SS Queda. August 1942
SS Tandra. January 1943
SS Masula. February 1943
SS Madura. February 1943
SS Melore. April 1943
SS Tandra. May 1943
SS Mulbera. July 1943
SS Malkura. October 1943
SS Querimba. February 1944

The point of this article is to provide evidence that the design of WW2 Radar equipment, and hence the maintenance practices, were vastly different from what we now experience in the 21st century. To illustrate this point by a simple and familiar example, if today our home DVD player of VCR breaks down, either the whole item is discarded in favour of a newer bigger brighter model, or for the impecunious (most of us), the faulty unit is diagnosed, removed and replaced. The new unit typically will contain the 1940s equivalent of 15 thermionic valves, 80 resistors and condensers, and 140 pieces of insulated wire, all painstakingly hand soldered together make the required electrical connections. In the1940s, if our home radio set broke down we would have taken it to a repair shop, where the failed tube (thermionic valve) was replaced, or the open circuit solder joint would be resoldered or whatever else needed to be done to allow us to continue listening to the likes of "Blue Hills" or "Dad & Dave".

So, whereas today the maintenance engineers might need a dozen or so sub assemblies for replacement needs, and have the luxury of built-in fault finding devices and in some cases the ability to program around the faulty unit, in the 1940s the maintenance teams needed to be supplied with hundreds, perhaps thousands, of the individual components. As well they required a number of discrete items of test equipment, and the availability of carefully drawn circuit diagrams to enable the failure to be isolated to in many cases, a burnt out resistor or a weakly emitting thermionic valve.

To provide the front line 1940s maintenance personnel with all the bits and pieces necessary to achieve the required high rate of fault repair, the procurement and supply infrastructure also had to be at a high level of efficiency and effectiveness. Given that the vast majority of maintenance needs were carried by very slow sea transport (no overnight helicopter or large air transport in those days), a lot of forward planning had to be done. As if this were not enough to contend with, there was also the contingency plans to be laid in the event one or more of the supply ships was sunk in enemy action.

In summary, the 1940s function of logistical inventory management of Radar associated equipment was, by comparison with today's program, a huge and very detailed task, and played a vital part in ensuring the Radar technicians had the logistical support for them to do their work.

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RADAR Basics

By Cherub Log

For most of those reading these Radar and related articles, the concept of the technology will be familiar. For those however who have had little or no exposure to Radar, this article will provide some of the basics.

A simple analogy is to imagine you are standing at Echo Point in Sydney's Blue Mountains, and you shout "Hello". Within a second or so your ear detects an audible echo. Now as the speed of sound is

known, and if you can accurately time the interval between your shout and the echo, the distance to the obstruction which caused the echo, e.g. mountain rock face, can be simply calculated. The formula is d distance = v velocity (of sound waves) multiplied by t/2 (half the elapsed time). The half is to allow for the sound to travel in both directions.

For Radar, instead of sound waves we have electromagnetic waves which have a velocity of 300 million metres per second. To measure time, there are a number of different electronic clocks which can be used and which can be highly accurate. As well, to do the arithmetic of t (time) multiplied by v (velocity) = d (distance), there are more electronic calculators. To illustrate, if a pulse of electromagnetic transmission is sent and the returned echo comes in 50 microseconds, the target is distant 7.5 kilometres as follows: d = v times t. Thus d = 3 x 10 to the power of 8, times 50 times 10 to the power of minus 6 =15,000 metres = 15Km. Thus the target is 7.5 Km distant

There are variations on this principle. One such is known as the Doppler Effect. Here it is not the time difference which is measured but the frequency difference. To explain Doppler effect, imagine you are standing on a railway station and you hear an approaching train, which in this case is an express train to pass straight through your station. As the train approaches, not only does the sound of it change in volume, but also the frequency or pitch of the sound changes slightly. In fact it increases as the train approaches, then decreases as the train leaves your station. This effect is caused by the velocity of the train's sound waves being increased by the velocity of the train as it approaches, and decreased similarly as the train roars off into the distance. So it is with electromagnetic waves in that there is a small frequency shift when there is a radial difference in range occurring between the Radar set and the target. As an example, at an operating frequency of 10 GHz (10,000 MHz or 3 centimetre wavelength) a radial velocity of 1 nautical mile (1.883 kilometres) per hour provides a Doppler frequency shift of 34 Hz. It should be noted however that the Doppler effect occurs only when there is a radial difference between the Radar set and the target. If both the Radar set and the target are travelling in a straight line at the same speed, Doppler effect will be zero because the relative distance separation remains constant, and thus no frequency shift. As well, if the target is moving in a circular path of constant radius about the Radar set, again there will be no frequency change, thus no Doppler effect.

In 1937 when the Home Chain system was introduced, there was one Radar function, that of early warning. In the 21st century there are many functions. Some are Control (Air Traffic Control), Navigation (Terrain Following Radar), Dock (Capsule Docking Radar), Land (Microwave Landing System), Map (Side-looking Radar)

All Radar systems need to obtain certain information. Typical are range, velocity and acceleration, azimuth direction, elevation angle, target signature.

In the immediate pre WW2 days, designs of the various thermionic valves limited the frequency at which a Radar system could operate. Typically this was in the high frequency range up to 50 Megacycles*, a wavelength of 6 metres. With the developments of the magnetron and klystron, frequencies up to 10,000 Megacycles , wavelength 3 centimetre, could be achieved. In the 21st century the Radar bands assigned by the International Telecommunications Union are as follows:

BAND	FREQUENCIES
VHF	138 – 144 MHz
	216 – 225 MHz
UHF	420 – 450 MHz
	890 – 942 MHz
L	1215 – 1400 MHz
S	2300 – 2500 MHz
	2700 – 3700 MHz
C	5250 – 5925 MHz
X	8500 – 10,680 MHz
Ku	14.4 – 14.0 GHz
	15.7 – 17.7 GHz
K	24.05 – 24.25 GHz
Ka	33.4 – 36.0 GHz

* The term cycles has been replaced in recent years by the term Hertz

The relationship between frequency , wavelength and velocity is constant where wavelength equals velocity divided by frequency. As an example, a wavelength of 30 centimetres will be derived from a velocity of 3 X 10 to the power of 8 divided by 1,000 MHz (1,000 X 10 to the power of 6.)

Again for the benefit of those not familiar with Radar, following are brief explanations of some of the words and terms used in these articles:

75 ohm coax Coax is the coaxial cable used to carry electromagnetic signals. The 75 ohm does not refer to standard direct current (DC) resistance. Typically the DC resistance in coax is zero. Here it is the impedance to alternating current signals. For maximum signal transference, the coax should exhibit the same impedance as that of the device to which it is attached, e.g. the receiving aerial, or the video amplifier etc.

A scan This is a single line horizontal trace on a cathode ray oscilloscope (CRO). At the left hand end, the large vertical pulse indicates the initial transmission signal. To the right along the trace, a returned echo is shown as another smaller vertical pulse.

A scope See “A” scan

Bedstead array Using a bit of imagination, this antenna looks very much like an old fashioned wire spring bed base, mounted on its long edge on the ship’s mast.

Bowden cable This is a strong flexible and usually lengthy cable used to transfer physical movement. For example, an operator in a Radar office turning a wheel that is connected by Bowden cable to the antenna on the mast head, can cause the antenna to move in the direction and by the amount that the operator desires

Double cheese This type of antenna looked like two half circular cheeses, but much larger.

Klystron Using the superhetrodyne principle of radio reception (see explanation of this), the klystron was used initially as a local oscillator. As the technology developed, more powerful klystrons were developed and used as transmitters.

Lantern Imagine an old fashioned cylindrically shaped lantern, but much larger. In this on the mast would be housed the Radar antenna, and in some cases much of the transmitting and receiving equipment.

M type transmission A 24 volt DC hand driven generator, when electrically connected to a similarly constructed motor, can cause the motor to turn in sympathy as the generator is turned. If the motor is mechanically connected to a Radar antenna, a Radar operator in the Radar shack could remotely turn the Radar antenna on the ship’s mast.

Magnetron This was one of the main transmitters. It could produce electromagnetic signals at frequencies between 10,000 and 3,000 MHz, for pulse durations of less than 1 microsecond, at pulse repetition rates of hundreds per second and with peak power outputs of hundreds of watts.

Micro dog This was a high power transmitting triode, NT98

Micro pup This was a low powered transmitting triode, NT99

Modulator This is simply the device which regulates the frequency, and sometimes the duration of the Radar transmission pulses

Motor alternator Standard electrical power supplies in HM ships during WW2, and for some time after, was 220 volts DC. All electronic equipment operated on alternating current (AC) at different voltages. A motor alternator was a DC electric motor mechanically connected to an alternator. Thus as power was applied to the DC motor, AC was delivered from the alternator.

PPI Plan Position Indicator was a circular Radar display (a modified cathode ray oscilloscope), with the source being at the centre of the circle. As the transmitter pulsed, a representative trace was projected on the screen emanating from the centre and extending to the periphery of the screen. A returned echo would be seen as a bright spot on the trace. As the antenna rotated, the PPI trace would rotate in synchronism. Thus not only the range of the target could be seen on the calibrated scale, but also its orientation in relation to ships head, of if desired, in relation to a fixed bearing such as magnetic or true north. Variations of this allowed the presentation of slant range of aircraft echos. Thus range, azimuth and altitude of aircraft could be quickly determined.

PRF Simply, pulse repetition frequency, or the number of transmitted pulses each second. These varied between Radars, but a PRF of 500 was typical.

Rx Shorthand for receiver

Sector sweep Refer to PPI. Instead of a 360 degree continuous rotation, some models were designed to allow backwards and forwards sweeps of a selected sector, e.g. 20 degrees both sides of ship's head

Spark gap This was one form of modulating transmissions. (See Jake Kerr's story of A272)

Superhetrodyne principle Amplification of electromagnetic signals is made more reliable by mixing the desired signal with one at a slightly different frequency, and by selecting the resultant difference. Thus the reflected echo signal of a magnetron transmission at 10,000 MHz, could be mixed with a klystron generated local signal of, say, 10,009 MHz. There would be 4 resultant signals i.e. the original two, the sum (20,009 MHz) and the difference (9 MHz). Selection of the 9 MHz for further amplification would produce the best frequency to be used to create the displayed echo signal.

Thermionic valve This was the forerunner to the transistor which in turn was the forerunner to integrated circuits, used in the millions today in radios, TV, mobile telephones etc. In appearance, generally it looked like a normal electric light globe. The principle of operation was that a constant stream of electrons would be emitted from the heated cathode, and the quantity of these electrons would be varied by an electric signal applied to the grid, placed physically between the cathode and the anode, which because it had a high tension voltage applied, would attract the cathode emitted electrons. In this process, the amplitude of the signal coming in to the grid would appear greatly magnified when seen at the anode. There were many variations of this device. The distance which the electrons had to travel from cathode to anode was a factor which determined the frequency limits of the valve in question.

Thiratron (Thyratron) This was a high power mercury vapour triode used as a pulse modulator for transmitters

Tx Shorthand for transmitter.

Variac A mechanical hand operated device for varying the voltage output of an alternator

Wave guide At lower frequencies, radio signals can be successfully carried over copper wire. At higher frequencies this does not work at all well. Waveguide is rectangular section metal tubing, sometimes gold plated on the inner surfaces. UHF and higher radio signals carry much more effectively along the inside of waveguide material. The length of the waveguide can be many metres without significant loss of performance. The dimensions of the cross section must relate to the frequency of the transmitted signal. A 3 cm transmission uses 3 cm cross section waveguide for example.

Wave Guide Horn See wave guide. At the antenna, the transmission signal leaves the waveguide and is directed to the antenna via an aperture or horn. For example, if the antenna is a parabolic reflector, the horn is located at the focal point, which may be up to 50 centimetres from the nearest point of surface of the reflector.

Yagi array An antenna array named after its Japanese inventor. Essentially it is a straight rod pointing away from the ship's mast in horizontal orientation. The active element which is connected to the transmitter is a transverse element, generally about 30% along the rod from the mast end. Nearest the mast are 2 or 3 transverse elements, slightly longer than the active element. These are the reflectors.

Then progressively located away from the active element in a forward direction, each slightly shorter than its predecessor and the active element are the directors. The net result is a highly directional antenna. Yagi antennas are common in domestic free to air television set ups.

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